

Pakistan Long-Term Low Emission Development Strategy Assessment

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Summary for Policy Makers

Summary for Policy Makers

This comprehensive report assesses the impacts of Pakistan's Long-Term Low-Emissions Development Strategy (LT-LEDS) across various dimensions, including economic growth, employment, social benefits, and environmental impacts.

In order to reinforce impacts of the LT-LEDS in decoupling productivity and emissions, planned renewable electricity generation capacity must take into account anticipated EV adoption and electrification efforts down-stream effects on electricity demand to ensure demand is satisfied by renewable sources. Further, strengthening emissions and efficiency standards in transport, industry, and buildings will improve returns and minimize impacts of economic growth on emissions. Nature-based interventions can also reduce agricultural emissions growth.

Significantly, the LT-LEDS results in a cumulative reduction of 1.6 billion tonnes of greenhouse gas emissions and a 19% annual reduction in emissions by 2050 over the business-as-usual (BAU) scenario (Figure 1a). This progress is largely attributed to the decarbonization of the transportation sector, with electric vehicles (EVs) surpassing fossil fuel vehicles (FFV) by 2043 and doubling FFVs by 2050.

The rapid electrification of transport increases electricity demand, slowing the transition to renewable energy sources and maintaining reliance on fossil fuel-based electricity generation due to the additional stress on generation capacity created. Challenging more extensive emissions reductions (Figure 1b).

The LT-LEDS fosters economic expansion, particularly in the services sector, and enhances green job creation, although it presents both short-term challenges and long-term gains. By 2050, GDP is projected to increase substantially under the LT-LEDS scenario due to the cumulative effects of growth driving investment and

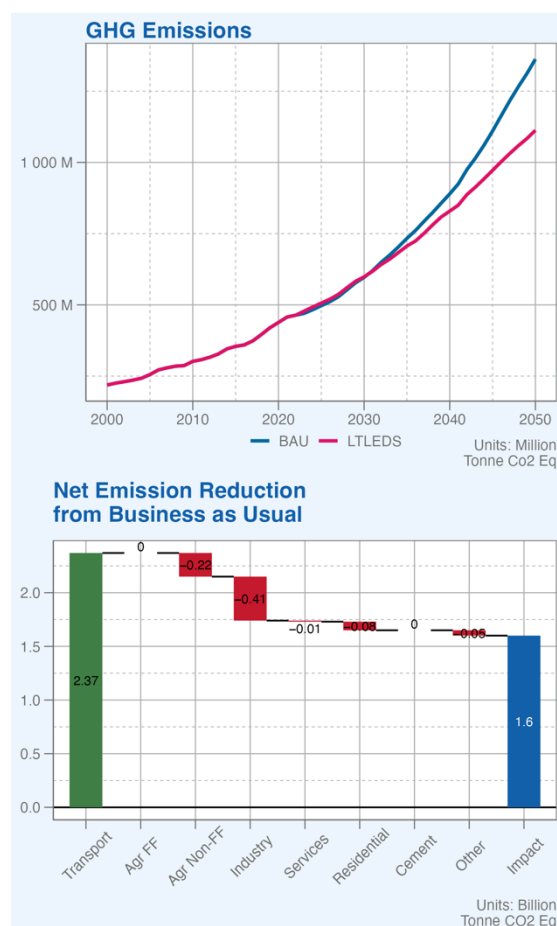


Figure 1: 1a. GHG Emissions in the BAU vs the LT-LEDS scenarios; Figure 1b. Emission reduction impact by emission source in LT-LEDS scenario

consumption; however, this also leads to increasing emission in agriculture and industry (Figure 1b).

Despite initial employment reductions, long-term growth in industry and services sectors is anticipated. Policy measures should to address employment shifts and trade deficits. Results suggest a gradual shift toward a service-oriented economy and increased efficiencies, highlighting the importance of aligning workforce skills with the emerging markets.

Modest improvements in life expectancy and managed water access. The results in the Just Transition Index of 2.5% increase over the BAU and limited progress on social factors emphasizes the need for optimized expenditure distribution and enhanced conservation measures to maximize societal benefits.

Key Impacts:

Emissions Reduction: A cumulative savings of 1.6 Billion tonnes of GHG emissions by 2050 with a 19 percent reduction of GHG emissions generated per year by 2050.

Electric Vehicle Adoption: EVs overtake FFVs by 2043 and make up nearly double by 2050, while FFVs peak in 2033 and return to 2010 levels by 2050, however electrification leads to the greatest increase in electricity demand, making up 49% by 2050.

Renewables Transition Challenges: Renewables as a share of electricity generation reaches 52% by 2050. Reduction in the proportion of fossil fuels generation slows after 2035 due to rapidly expanding electricity generation.

Economic Growth: LT-LEDs significantly boost GDP, with an increase of 23,986 billion PKR by 2050, primarily driven by the service sector, resulting in a cost-benefit ratio of 4.4 by 2050.

Sector Contributions: The services sector experiences the most significant growth, with its Gross Value Added (GVA) increasing by 12.6% by 2050 under LT-LEDs, compared to smaller gains in agriculture and industry sectors.

Investment Growth: Gross Fixed Capital Formation (GFCF) sees substantial growth under LT-LEDs, particularly in the services and industry sectors, reaching a total investment of 15.72 trillion PKR by 2050, reflecting the strategy's emphasis on capital accumulation.

Trade Balance: The LT-LEDs scenario shows increased imports and exports, with a more rapid growth in imports leading to a widening trade deficit, particularly in agriculture and services, highlighting the need for stronger domestic supply chains.

Employment Trends: Initial negative impacts on employment are observed, with a loss of 19,562 jobs by 2030 compared to the baseline, but long-term gains result in 54,063 new jobs by 2050, especially in industry and services.

Sectoral Employment Shifts: Agricultural employment declines over time, while industrial employment rises, and the services sector remains relatively stable.

Green Job Creation: The adoption of green technologies results in approximately 150,000 new jobs by 2050, with the most significant changes observed in the industrial and agriculture sectors.

Education and Employment: There is a notable increase in employment for individuals with no schooling, but fewer opportunities for those with secondary and tertiary education.

Just Transition Index (JTI): The JTI shows a positive impact of 2.5% by 2050, with improvements in GDP per employed person and social transfers expenditure, but a slight negative impact on income inequality.

Social Benefits: Marginal improvements in life expectancy and managed water access, with a 10% increase in water access and slight increases in life expectancy by 2050, emphasizing the need for enhanced social policy integration.

Environmental Benefits: Positive impacts on biodiversity are observed under implementation of LT-LEDs, reflecting an increase of 14% in the 'Red List Index' by 2050.

The Pakistan LT-LEDS Assessment

The Long-Term Low Emission Development Strategy Assessment

The project for “Scenario Modelling and Macroeconomic Assessment including Multi-sectoral Cost/Benefit Analysis and Impacts of Long-Term Low Emissions Development Strategies (LT-LEDS)” is implemented under the purview of the United Nations Development Programme country office of Pakistan. The LT-LEDS is intended to establish a vision and national framework for low-carbon development where economic growth is decoupled from emissions. This project is one in a portfolio of projects intended to scope, discuss, and shape the direction of the LT-LEDS in Pakistan.

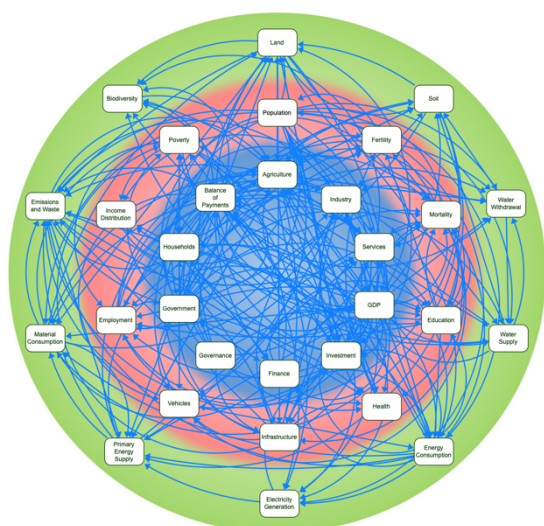


Figure 1. Overview diagram of the iSDG model including Economic (Blue), Social (Red), and Environmental (Green) sub-models

This exercise was implemented by using the Millennium Institute’s (MI) Integrated Sustainable Development Goals model (iSDG). The MI is a nonprofit, non-governmental organization dedicated to supporting governments and organizations in designing strategies that lead to measurable progress in sustainability transition, and has worked in over 40 Countries since it’s founding in 1983 (Allen, 2019; Allen, 2021; Pedercini, 2018; UNEP,

2011). The iSDG is a peer-reviewed (Allen, 2016), integrated, simulation model that includes social, environmental, and economic components, and is used for testing scenarios of policy impact on key developmental indicators (Collste, 2017).

Scenario and Impact Definitions

The project implements two scenarios: a policy scenario (LT-LEDS) and a baseline scenario to measure impact against (business-as-usual). The business-as-usual, or BAU, takes recent government expenditure as a percentage of GDP, and implments future expenditure as a constant percentage of GDP. This ensures that expenditure adjusts with inflation. The LT-LEDS scenario adjusts the expenditure on top of the BAU.

Anticipated LT-LEDS expenditure is derived from figures detailed in *Pakistan’s Nationally Determined Contributions (NDC) Investment Plan*; an output of a project within the portfolio of UNDP’s LT-LEDS projects. This additional expenditure is mapped to inteventions in the iSDG model and implemented until 2050. These interventions include agriculture, building and industry energy efficiency, water and sanitation, education, and health policies, among others.

Additional to these interventions, planned electricity generation capacity is implemented until 2030, and then driven by market dynamics base on the long-term costs of electicity generation. Lastly, the anticipated targets for electric vehicle adoption are implemented in line with NDC targets.

These two scenarios are used in order to measure the impact of the implemented expenditure and policies in the LT-LEDS. This is done by removing the BAU from the LT-LEDS timeseries simulation data for a given indicator. This difference provides the estimated impact that the LT-LEDS will have over the BAU scenario.

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Macro-economic Assessment of the LT-LEDS

Macro-economic Assessment of the Long-Term Low Emission Development Strategy

Macro-economic performance that arises from the implementation of the Long Term Low Emission Development Strategy (LT-LEDS) scenario in Pakistan shows significant growth out to 2050 in terms of real output and domestic investment, particularly for the services sector due to compounding returns on investment and stimulated spending and consumption. Growing trade relations lead to industry trade balances improving while the agriculture trade deficits continue to grow.

Behavior of and impacts on Real Gross Domestic Product (GDP), sector Real Gross Value Added (GVA), aggregate and sector level employment figures, Real Imports and Exports at aggregate and by sector, and Government Debt to GDP Ratio are used to describe the macro-economic development landscape of Pakistan until mid-century, with indicators compared between the LT-LEDS and Business-as-usual (BAU) scenarios and based on the impact, or difference, between the LT-LEDS and BAU.

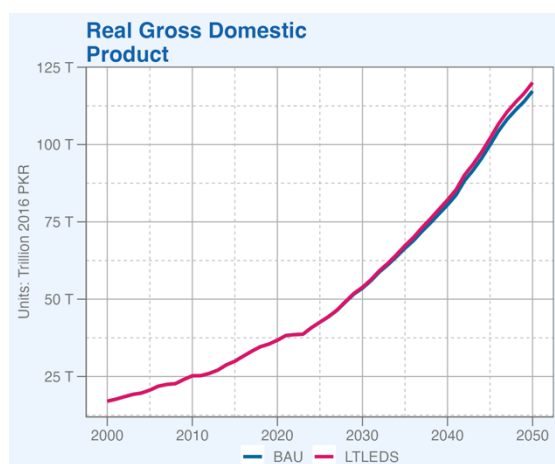


Figure 1. GDP under the BAU and LT-LEDS scenarios

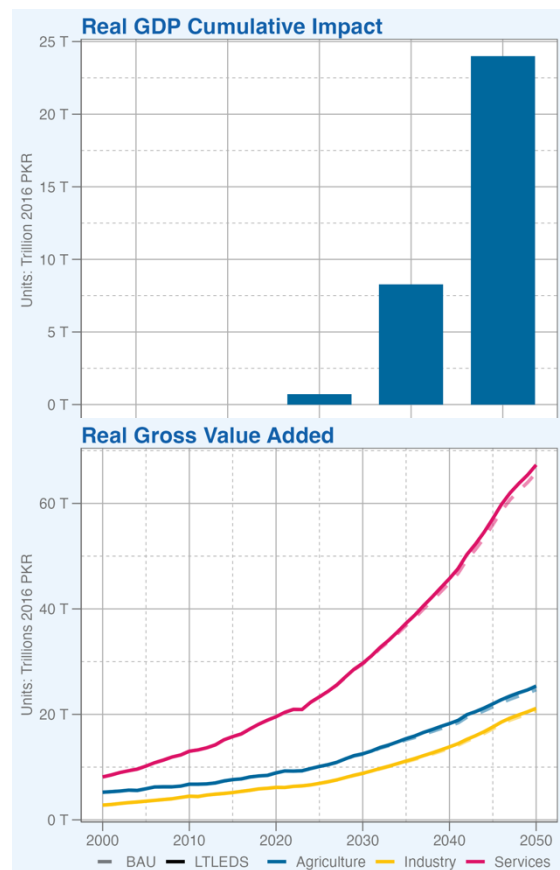


Figure 2a. cumulative impact of LT-LEDS over 10 year decadal periods; 2b. sector gross value added for LT-LEDS and BAU scenarios

1. Gross Domestic Product and Gross Value Added

GDP demonstrates consistent growth across both scenarios, however the LT-LEDS scenario returns greater impact compared to the Business-as-usual (BAU) with a widening gap by mid-century. By 2050, the GDP under the LT-LEDS scenario reaches approximately 120.05 trillion 2016 PKR compared to 117.30 trillion under the BAU scenario (Figure 1). This represents an absolute increase of 2.75 trillion 2016 PKR per year in 2050. The compound annual growth rate (CAGR) for the LT-LEDS scenario from 2020 to 2050 is slightly higher at approximately 4.1% compared to 4.0% for the BAU scenario; illustrating the reinforcing impact of gradual accumulated differences in GDP over time.

The impact of the LT-LEDS scenario over the BAU scenario becomes more pronounced over time. In 2030, the impact is approximately 512.86 billion, and it continues to widen, reaching 2.75 trillion by 2050. These impacts result in a cumulative impact of approximately 8 trillion in the 2030's and 23 trillion in the 2040's (Figure 2a).

2. Sector Contribution to GDP

This growth in output reflects economic expansion across all sectors in absolute terms for each scenario, however the LT-LEDS scenario leads to increased growth rates, most predominantly, in services and agriculture, and to a lesser extent in Industry (Figure 2b). Increases in output are driven by greater technological adoption due to growth in trade, greater educational attainment, as well as improvements in health leading to increases in life expectancy.

From 2020 to 2050, the LT-LEDS scenario shows significant improvements in real GVA across all sectors compared to the BAU scenario. Agriculture GVA increases from 8.90 trillion in 2020 to 25.36 trillion in 2050 under the LT-LEDS scenario, representing an absolute increase of 2.87 trillion or 11.6%. Industry also sees a notable rise, yet more muted than agriculture, growing from 6.15 trillion in 2020 to 21.14 trillion in 2050, with a 21.5% increase by 2050. The services sector experiences the largest growth, increasing from 19.56 trillion in 2020 to 67.31 trillion in 2050, showing a substantial 6.73 trillion or 12.6% rise.

Over the period, there are significant shifts in the contributions of each sector to GDP. In the BAU scenario, the services sector remains the largest contributor, increasing its share from 53.2% in 2020 to 56.2% in 2050. While, in the LT-LEDS scenario, the services sector's share rises more markedly by 20 basis points. While the

agriculture and industry sectors slightly reduce their shares in both scenarios. The growth seen in Services highlights a broader structural shift towards service-based activities within the economy. This is driven by greater relative return-on-investment for capital in the services sector driving investment priorities.

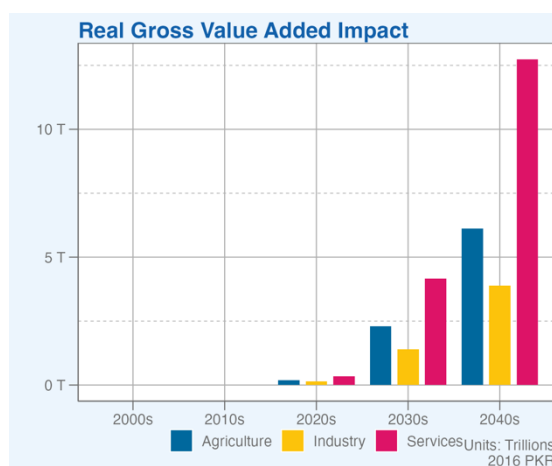


Figure 3. Gross Value Added impact of LT-LEDS over the BAU scenario

The impact of the LT-LEDS scenario over the BAU scenario is significant across all sectors (Figure 3). Agriculture sees an impact of 3.88 billion in 2024; growing to 671.27 billion by 2050. The industry exhibits an impact of 2.57 billion in 2024, reaching 445.62 billion by 2050. While, services sees the most significant impact at 7.94 billion in 2024 and increasing to 1.48 trillion by 2050. These impacts highlight the effectiveness of the LT-LEDS policies in driving sectoral growth and contributing to overall economic development, with the services sector showing the most substantial gains.

While both BAU and LT-LEDS scenarios project significant economic expansion in terms of GDP and GVA across sectors, the LT-LEDS scenario generally presents more optimistic growth trajectories. This reflects differing assumptions about future capital and labor efficiency advancements, electrification, and decarbonization that shape these projections.

3. Gross Fixed Capital Formation

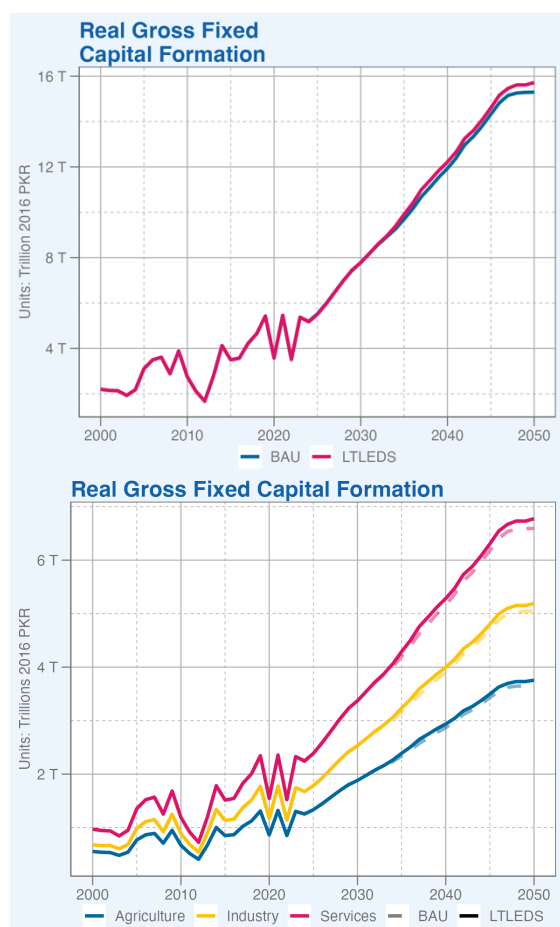


Figure 4a. Gross fixed capital formation in the BAU and LT-LEDs scenario; 4b. Sector level investment for each scenario

Gross Fixed Capital Formation (GFCF), or Investment, sees substantial growth from 2020 to 2050, and the LT-LEDs scenario demonstrates a notable improvement in total real investment compared to the BAU scenario (Figure 4a). This growth is due to greater levels of GVA generating new capital, particularly in the services sectors, as well as increased government expenditure stimulating consumption. These increases in investment flows are driven by private domestic direct investment, as foreign direct investment and public capital investment are assumed to remain the same across scenarios.

By 2050, investment under the LT-LEDs scenario reaches approximately 15.72 trillion, compared to 15.29 trillion in the

BAU scenario, reflecting an increased CAGR by 10 basis points of 3.4%. Increased growth rates of investment under the LT-LEDs scenario is particularly noticeable from 2030 onwards. By 2040, investment under the LT-LEDs scenario is 14.60 trillion compared to 14.32 trillion in the BAU scenario and approximately 16 trillion by 2050. The impact of the LT-LEDs scenario over the BAU scenario becomes increasingly significant over time, with an additional 39.90 billion at 2030, 218.15 billion by 2040, and 428.61 billion per year by 2050.

From 2020 to 2050, the LT-LEDs scenario shows improvement in real investment across all sectors compared to the BAU scenario. In the agriculture sector, investment under the LT-LEDs scenario grows from 1.31 trillion in 2020 to 3.76 trillion in 2050, compared to 3.65 trillion in the BAU scenario, reflecting a CAGR of 4.0% versus 3.9%. Industry investment increases from 1.77 trillion in 2020 to 5.19 trillion in 2050 under LT-LEDs, compared to 5.05 trillion under BAU, with CAGRs of 4.1% and 4.0%, respectively. The services sector, the largest contributor, sees investment rise from 2.36 trillion in 2020 to 6.77 trillion by 2050 under LT-LEDs, compared to 6.59 trillion under BAU, showcasing CAGRs of 4.2% and 4.1%.

There are only marginal shifts in the share of each sector's investment observed over the period. In the BAU scenario, agriculture's share decreases marginally from ~23% but remains stable overall, while services increases marginally, but also remains overall stable at ~27%. Industry sees the only measurable increase over the period, growing 1% from 49% to 50%. Meanwhile, the LT-LEDs scenario follows similar patterns, with slightly increased growth in shares for the industry and services sectors, while agriculture drops marginally.

Due to the compounding of capital accumulation, the impact of the LT-LEDs scenario over the BAU scenario becomes

increasingly significant over time. In agriculture, the impact is relatively minor initially, but it grows to approximately 100 billion by 2050. Industry sees a substantial impact, with investment differences reaching 141 billion by 2050. The services sector experiences the largest impact, with additional investments of approximately 183 billion by 2050. The LT-LEDS reinforces the underlying economic trends towards a growth in service-base activities and further industrialization.

4. Imports and Exports

The LT-LEDS scenario demonstrates a significant increase in both real imports and exports compared to the BAU scenario stimulated by greater intermediate and final consumption as well as capital efficiency (Figure 5a). For imports, the LT-LEDS scenario shows a steady rise from 9.21 trillion in 2020 to 33.84 trillion by 2050, compared to 32.94 trillion under the BAU scenario. Exports under the LT-LEDS scenario also increase from 5.20 trillion in 2020 to 24.33 trillion by 2050, compared to 23.75 trillion in the BAU scenario. Export growth is driven by increased sector efficiency from TFP improvements as explained in the section on GVA. Growth in imports on the other hand are largely driven by increased government consumption expenditures.

Imports shows a growing impact from 3.43 billion in 2023 to a substantial 898 billion by 2050, while exports experience an even more considerable impact, starting at 2.57 billion in 2024 and reaching 581 billion by 2050. These figures highlight a widening gap in trade, with imports growing more rapidly. This trend suggests that without broader trade policies targeting expanding domestic supply chains, the trade deficit trend will continue.

At the sectoral level, industry trade balance nearly reaches parity by 2050, while agriculture exports stagnate and imports grow rapidly (Figure 5b). Services remain

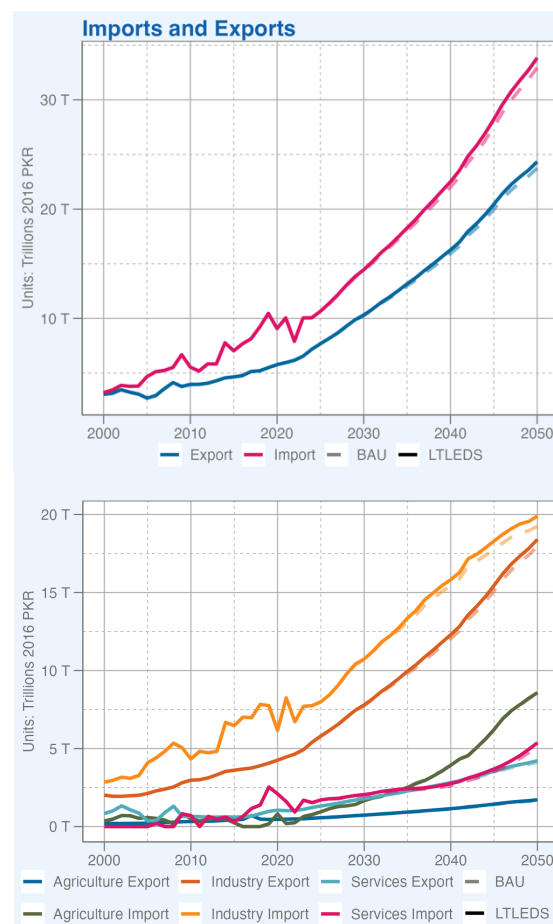


Figure 5a. total imports and exports in LT-LEDS and BAU; 5b. Sector level imports and exports for each scenario

largely comparable until mid-century with imports growing in demand. Agricultural imports in the LT-LEDS scenario grows from 8.13 trillion in 2020 to 8.58 trillion by 2050, compared to 8.53 trillion in the BAU scenario. Industrial imports see significant growth from 6.15 trillion in 2020 to 19.89 trillion in 2050 under LT-LEDS, compared to 19.23 trillion under BAU. The services sector, starting from 2.10 trillion in 2020, reaches 5.37 trillion in 2050 under LT-LEDS, compared to 5.17 trillion under BAU.

Exports exhibit significant improvement under the LT-LEDS scenario. Agricultural exports rise from 462.32 billion in 2020 to 1.72 trillion by 2050, compared to 1.68 trillion under BAU, with CAGRs of 5.0% and 4.9%, respectively. Industrial exports grow from 4.25 trillion in 2020 to 18.40 trillion in 2050 under LT-LEDS, compared to 17.96 trillion under BAU, reflecting

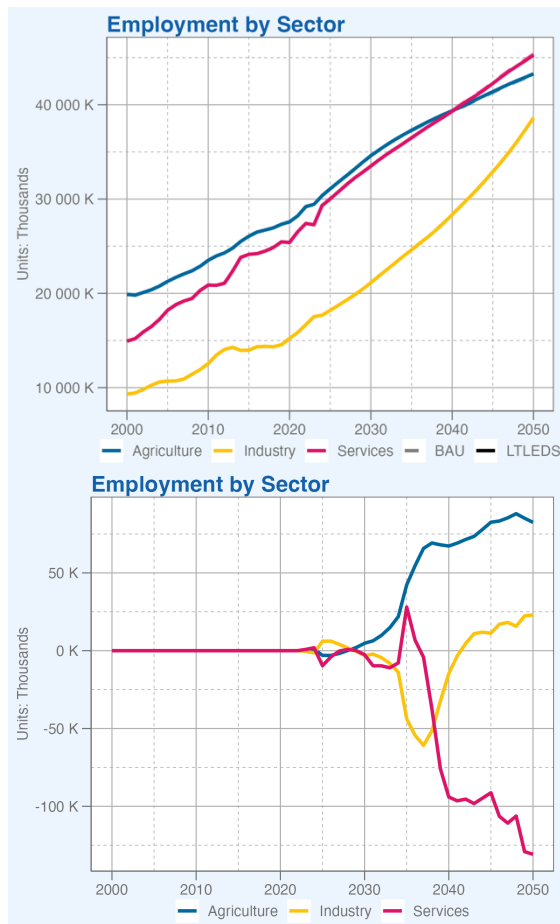


Figure 6. 6a. Sector level employment in the LT-LEDS and BAU; 6b. Sector level employment impact of LT-LEDS over the BAU

CAGRs of 5.6% and 5.5%, respectively. This highlights the rapid growth of industry exports contributing positively to trade balances. Exports in the services sector increase from 1.05 trillion in 2020 to 4.22 trillion by 2050 under LT-LEDS, compared to 4.12 trillion under BAU, with CAGRs of 5.0% and 4.9%, respectively. Agriculture and services exports remain stagnant in growth rate, and could be seen as opportunities to positively impact trade.

Agricultural imports impact is marginal by 2050, while industrial imports and, further exports, experience a substantial impact, with differences reaching 65.74 billion and an additional 439.51 billion by 2050, respectively. The services sector sees an impact starting at 2.50 billion in 2020 and growing to 99.47 billion by 2050. On the export side, agricultural exports benefit

from an additional 409.99 billion by 2050, and services exports from an additional 100.78 billion by 2050.

5. Employment

From 2020 to 2050, the LT-LEDS scenario shows stable growth in total employment compared to the BAU scenario (Figure 6a). By 2050, total employment under the LT-LEDS scenario reaches approximately 127.18 million, slightly lower than the 127.21 million under the BAU scenario. The LT-LEDS scenario experiences minor dips compared to the BAU scenario due to fluctuations in employment growth, particularly between 2040 and 2050.

The employment composition by sector reveals important shifts in the percentage of each sector's total employment. Under both scenarios, agricultural employment slightly decreases as a percentage of total employment, dropping from approximately 40% in 2020 to around 34% in 2050. Industrial employment sees a stable increase, maintaining around 29% by 2050 under both scenarios. However, services employment grows from about 31% in 2020 to approximately 36% in 2050. These shifts indicate a gradual transition towards a more service-oriented economy, with the LT-LEDS scenario accelerating this trend slightly more than the BAU scenario.

The impact of the LT-LEDS scenario over the BAU scenario is noticeable in sector-specific employment changes (Figure 6b). Agricultural employment under the LT-LEDS scenario shows a positive impact, with an increase of about 85,378 jobs by 2050. Industrial employment sees a slight reduction of around 22,986 jobs, while services employment decreases by 130,847 jobs by 2050 under the LT-LEDS scenario compared to the BAU scenario. These figures highlight the nuanced effects of LT-LEDS policies, which reinforce existing trends shifting employment within sectors, but also reinforce increased efficiency in service and industry sectors.

Assessing the Impacts on Green Jobs and a Just Transition in a LT-LEDS

Assessing the Impacts on Green Jobs and a Just Transition in the LT-LED Strategy

This chapter assesses the impacts in relation to in green job creation and just transition measures arising from the testing of a LT-LEDS scenario in Pakistan. Proposed emission reductions arise through the adoption of green technologies and processes that result in the creation of green jobs. To ensure that the LT-LEDS does not leave anyone behind, the analysis includes a Just Transition Index, to quantify the societal benefits in terms of select indicators. This allows for a comparative assessment to measure the effectiveness of policies towards achieving an inclusive and just transition.

1. Green Jobs: identification and categorization

Broadly, Green jobs are defined as the employment created which reduce sectors' environmental impacts. Green Jobs includes "decent" jobs that reduce consumption of energy and raw materials, de-carbonize the economy, protect and restore ecosystems and biodiversity and minimize the production of waste and pollution (ILO, 2011).

The approach followed in the modelling analysis involves quantifying green jobs as the outcome of government's green investments. Such investments include those in the renewable energy sector, investments in efficiency for both industrial and households' energy, investments in efficiency for water uses and vehicles efficiency and finally, investments in waste management, reforestation and climate change adaptation. Jobs attained through the implementation of the LT-LEDS scenario are therefore assumed to be 'green' since these are created through direct investments in LT-LEDS policy.

The analysis further investigates the level of education required for the employment created as a way of measuring labour skill requirements. This facilitates a supply and demand assessment between the labour market and the education system.

Key variables focused on during the green jobs assessment include:

- Total employment
- Employment by sector (agriculture, industry and services)
- Employment by education level (non-schooling to tertiary level).

2. Just transition: principles and components

The International Labour Organization (ILO) defines a Just Transition as: "Greening the economy in a way that is as fair and inclusive as possible to everyone concerned, creating decent work opportunities and leaving no one behind."

The approach followed in this analysis included identifying a set of key performance indicators (KPIs) to measure and quantify a Just Transition Index (Table 1). These KPIs were identified as those that are key in capturing employment centred economic growth, social protection, labour market dynamics and skill development. Thereafter, the index performance is



Figure 2. Absolute change in total employment between the BAU and LT-LEDS scenario (units: 1000 persons).

assessed to measure just transition progress in the LT-LEDS scenario.

Table 1. Select indicators to represent the composite behaviour of the Just Transition Index.

Just Transition Index	
JTI 1	GDP per employed person: to capture employment centred economic growth
JTI 2	Per capita social and education transfers expenditure: To capture the social policy intended to safeguard workers from transition impacts
JTI 3	Total employment: To include the job creation-oriented policy
JTI 4	Average employment-education supply demand gap: To represent skill development component
JTI 5	Gini coefficient: to include income inequality

3. Findings of the green job assessment

In this section we present the impact analysis of green job creation in relation to employment and education dynamics. Pakistan, with a rapidly growing population of 213 million, has a national labour force of 71.76 million, of which 67.25 million are employed, accounting for 45% of the total population. A significant gender disparity exists within the workforce, while 67.9% of men participate in the labour force, women's participation is considerably lower at 21.5% (Government of Pakistan, 2022). In this section we present the impact analysis of green job creation in relation to employment and education dynamics.

Figure 1 illustrates the net change in total employment between the policy and the BAU scenario following the year 2024, the beginning of the investment period, until 2050. The maximum change in job creation is approximately 20,000 employees more in the LT-LEDS scenario, occurring around 2035, with a minimum change of approximately less 40,000 employees around 2038, representing 0.025% and 0.05% of the total workforce respectively.

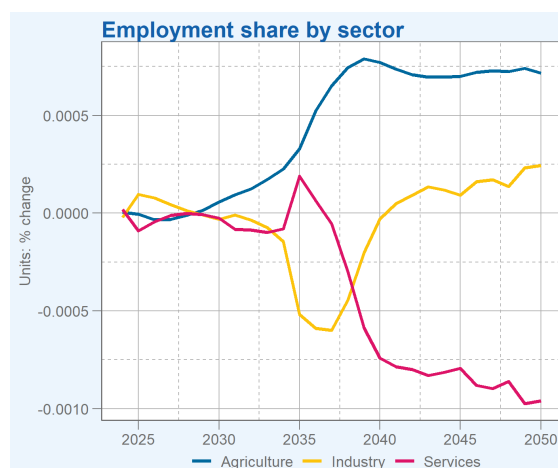


Figure 3. Percentage change in the employment share by sector between the BAU and LT-LEDS scenario.

In the BAU scenario, it is noted that the growth rate of agriculture related jobs decline over time, passing from 39.25% in 2024 to 33.70% of total employment by 2050. This growth rate is lost in favour of industry employment, that increases from 22.85% to 30.70% over time. Services employment as a share of total employment experiences marginal overall adjustments, decreasing by 2.30% by 2050. Similar trends are observed in the LT-LEDS scenario, with a noticeable loss of agricultural employment in favor of industrial jobs, and a services sector that remains quite stable. These results are characteristic of low-income countries,

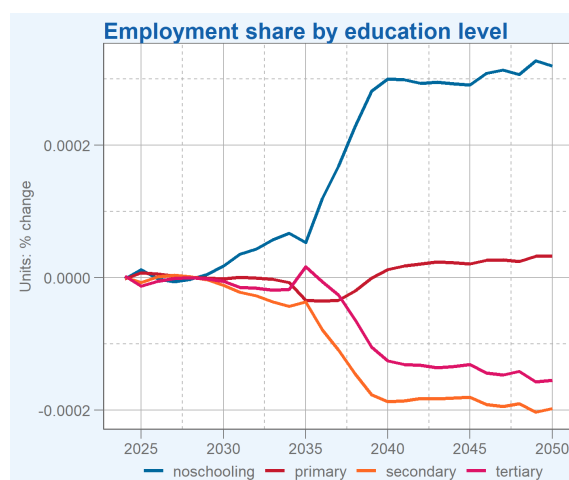


Figure 4. Percentage change in the employment share by education level between the BAU and LT-LEDS scenario.

where progressive development results in a shift in labour demand from agricultural activities to industrial and service orientated jobs (ILO, 2018).

Figure 2 illustrates the percentage change for the share of employment per sector (Agriculture, Industry and Services) between the BAU and LT-LEDS scenario. Notably, there is a decrease in the absolute employment share per sector over time, though the change in employment share between the BAU and LT-LEDS scenario are marginal, with the largest impact observed for the agriculture sector (Figure 2).

Figure 3 similarly shows the share of employment per education level, disaggregated into four education level categories: no schooling, partial or full completion of primary school, partial or full completion of secondary education, and partial and full completion of tertiary education. The differences between the BAU and LT-LEDS scenario are marginal with minor changes in the increase of jobs among the four education levels, with the largest change observed in the no schooling category (Figure 3).

In absolute terms, employment for the no schooling category increases by approximately 38 000 persons, with decreasing values observed for the secondary and tertiary education categories (Figure 4). This suggests that employment opportunity and the creation of 'green jobs' that require greater levels of education are marginally less than in the BAU scenario, specifically for the secondary and tertiary educated population, though there is an increase in employment opportunity for lower-skilled workers.

The analysis on green job creation reveals subtle impacts on employment and education outcomes. In terms of sectoral impacts, employment in the agricultural sector shows a decline with only a slight increase observed in the LT-LEDS

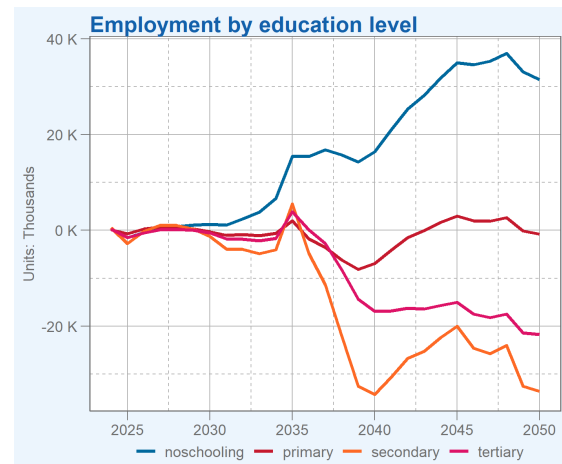


Figure 5. Absolute change in the employment share by education level between the BAU and LT-LEDS scenario.

scenario, whereas, industrial employment slowly rises, while the services sector remains stable. In terms of education, green job creation marginally affects employment distribution across education levels, with the most notable increase in jobs for individuals with no schooling. This highlights the need for targeted education and vocational training initiatives to align workforce skills with emerging green job markets.

Though the LT-LEDS scenario does not reflect substantial gains in employment, it may result in a transfer of skills between jobs. Moreover, it may be that existing jobs are substituted with 'green jobs' resulting zero net change. Nonetheless, expected green jobs in agriculture can include those in sustainable farming and efficient irrigation technologies, which can require varying levels of education, with varying accreditation programmes.

In the industry sector, green jobs are expected to arise in the energy and road transport sector, considering the rising demands in renewable-based generation capacity and electric-vehicle (EV) energy needs. Many industry-based jobs will require more advanced levels of education, with dedicated curricula dedicated to the secondary and tertiary level, though dedicated reskilling programmes could also be provided through Technical Vocational

Education Training (TVET) centres. Lastly, green jobs that can arise from the service sector can include roles in climate finance, carbon accounting and emission monitoring, reporting and verification (MRV). This can require certifications from basic training in schooling to tertiary-level education including, but not limited to, environmental management, finance and accounting.

4. Findings of the Just Transition assessment

This section presents the impact analysis of the LT-LEDS scenario on a Just Transition, measured through a composite Just Transition Index (JTI) quantified and weighted evenly using the select just transition indicators shown in Table 1.

Figure 5 illustrates the change between the BAU and LT-LEDS scenarios for the JTI and its inclusive indicators, where a positive change represents a higher policy impact in comparison to the BAU (except for JT5, the Gini coefficient). The impact of the indicators is as follows. The LT-LEDS scenario produces a stronger GDP per employee growth (JTI 1) than the BAU scenario, owing to interventions implemented improve productivity. This results in a higher GDP distributed across employed persons. Similarly, the LT-LEDS scenario produces a higher education and social transfers expenditure (JTI 2) as a result of a greater GDP growth. The LT-LEDS scenario has no considerable effect on the total employment (JTI 3). Moreover, the LT-LEDS scenario reinforces the employment-education supply-demand gap, as the effect of the investments in the education system are more effective than in job creation (JTI 4). As such, the interventions are effective in developing skills but fail to create jobs to support a more educated population over the BAU. Lastly, the LT-LEDS scenario has a marginal to slight positive impact on inequality reduction compared to the BAU (JTI 5), reflecting a minor improvement

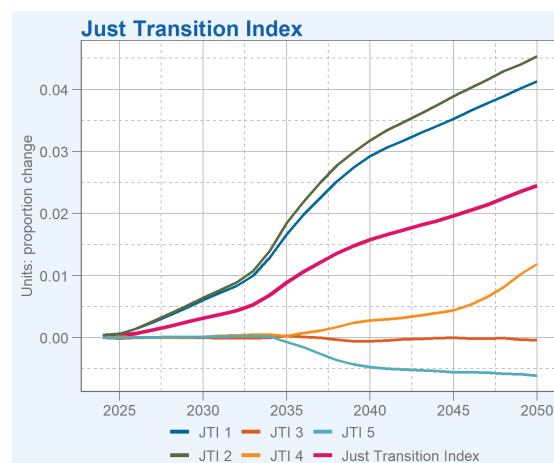


Figure 6. Percentage change in the aggregated Just Transition Index (in bold magenta) and related indicators between the BAU and LT-LEDS scenario. JTI 1 in dark blue (GDP per employed persons), JTI 2 in dark green (social and education transfers expenditure), JTI 3 in red (total employment), JTI 4 in orange (employment-education gap) and JTI 5 in light blue (gini coefficient).

(~1%) in the distribution of income across the total population. Despite being modest overall, the change in the Just transition Index shows a positive impact of 2.5% by 2050 based on the impacts of the respective indicators. This suggests that implementation of more-targeted social policies may be required to achieve larger synergies on social impacts.

5. Examples of successful just transition initiatives and case studies

This section provides an overview of how the just transition framework has been integrated in previous LT-LED strategies, with a few examples of successful case studies across different countries.

Firstly, the IPCC6 LT-LEDS synopsis synthesizes outcomes from 68 latest available strategies from 75 member parties to the Paris agreement. According to the synopsis, the just transition concept is widely recognised, with 81% of the LT-LEDS acknowledging components of just transition, and recognising elements around fairness, equity and inclusiveness

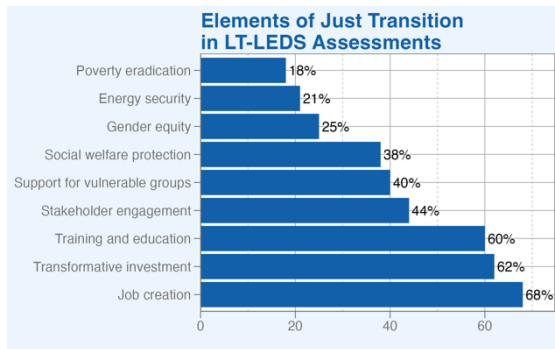


Figure 7. Common elements of a just transition included in LT-LED assessments across member states of the Paris Agreement (Adapted from UNFCCC, 2023).

in the strategies. The synopsis report further outlines the common elements of just transition, with the most studies including 'job creation', 'investment for economic transformation' and 'training and education' (Figure 6). Elements around the just transition varied across countries, where other diverse measures include training programs to upskill or reskill workers, incorporating climate change into educational curricula and offering incentives and investments to encourage job creation in emerging markets.

Other interesting just transition initiatives have evolved with the development of LT-LED strategies with emphasis on successful case studies below.

- **Just Transition Fund in the EU** (European Commission, 2020): The European Union's JTF aims to support regions and sectors that will be most affected by the transition to a green economy. It provides support, through the JT funding mechanism, for job creation and economic diversification in coal and carbon-intensive areas.
- **South Africa's Just Energy Transition Partnership (Presidential Climate Commission, 2022)**: Establishment of the presidential climate commission to develop and oversee the implementation of a just transition framework. Also,

established the Just Energy Transition Investment Plan for the five-year period 2023-2027 sets out the scale of need and the investments required to achieve the decarbonisation commitments as outlined in the Nationally Determined Contribution.

- **Canada's Just Transition Strategy (Government of Canada, 2019)**: Canada has implemented strategies to support workers in fossil fuel industries through retraining programs and investment in clean energy sectors, emphasizing equitable job creation.
- **Scotland's Just Transition Commission (Consumer Scotland, 2023)**: Scotland established a commission to advise the government on transitioning to a net-zero economy, focusing on inclusive policies that support workers and communities impacted by the transition. This facilitated the development of the current 'Climate Skills Action Plan' that notes the need for development of specialist knowledge and skills in energy management in buildings services. Further, Consumer Scotland welcomes the £875 million investment in Green Jobs, skills and energy transition.

Guidelines provided by the International Labour Organization (ILO, 2015) towards achieving low-carbon growth state that:

- Countries require a tailored mix of policies to support sustainable industries and to create decent work opportunities
- Institutional arrangements must involve stakeholders at various levels
- Macroeconomic policies should promote sustainable production and consumption, align economic growth with social and environmental goals, and utilize regulations like taxes and subsidies.

- Public funds should be invested in green initiatives

Moreover, an assessment of successful just transition initiatives by the World Resources Institute highlighted three common ingredients to ensure equitable and just planning (Bouyé, Tankou and Grinspan, 2019):

- Involvement of affected workers and communities
- Anticipation of negative impacts through long-term scenario planning to foresee and address potential negative impacts
- Support through targeted financial programs and capacity building that prioritizes the vulnerable population

These ‘ingredients’ were identified based on five case studies, including the ‘EU support to Coal regions’ initiative which aims to provide technical and knowledge assistance to EU regions that are transitioning to a low-carbon economy. An initiative in Spain that focused on investment in mining communities to support early retirement, green job training and environment restoration. Two successful initiatives were highlighted in Latin America (Mexico and Peru), both emphasising the importance of community-based and indigenous adaptation methods. Lastly, in Uganda, policies have been developed to provide compensation to landowners and means to diversify income from land ownership.

These initiatives illustrate how just transition and green jobs principles are implemented in various countries. Though many initiatives have been implemented in high income countries, low to lower-middle income countries have similarly progressed in addressing the just transition e.g. South Africa, Mexico, Uganda.. Pakistan, classified as a lower-middle-income country, shares similar development challenges with neighbouring South Asian

countries. Despite experiencing a reduction in poverty between 2001 and 2015, poverty levels—measured by the poverty headcount ratio of \$3.20 a day (2011 PPP), remain below the regional average for South Asia and lower-middle-income nations (World Bank, 2022).

Gender disparity in employment remains significant, with women being disproportionately excluded from economic opportunities. While 67.9% of men participate in the labor force, only 21.5% of women are active, and women make up the majority of the unemployed, representing just 24% of the total labor force (Government of Pakistan, 2022).

Additionally, education attainment is notably low, particularly for girls and young women. According to the LT-LEDS scenario findings, a substantial portion of the population has no formal schooling, contributing to the broader gender gap in employment and opportunities (World Bank, 2022).

Given this context, just transition initiatives and green job programs arising from the LT-LEDS should prioritize:

- Skill development in key LT-LEDS focus areas, particularly within sectors such as renewable energy, transportation and electric vehicle technologies, sustainable agriculture, and conservation.
- Initiatives that focus on reskilling, for example, training farmers on more efficient water irrigation techniques to enhance productivity.
- Work programs must aim to include marginalized groups, particularly girls and young women, to help close gender gaps in education and employment opportunities.

Many countries still have a long-way to go to reaching net-zero and are therefore

expected to test pilot just transition and green job programmes. Ongoing research and pilots are also necessary to develop methods of best practice, and better establish success stories in the local

context. This highlights that careful, long-term planning is essential to achieve a just transition in during implementation of the LT-LEDS .

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Assessing the Costs and Benefits of Implementing the LT-LEDS

Assessing the Costs and Benefits of Implementing the LT-LED Strategy

This chapter assesses the direct and indirect impacts arising from the implementation of a LT-LEDS scenario in Pakistan and presents the relative costs and benefits in relation to key national development outcomes. A LT-LEDS aims to reduce emissions to increase societal value in the long-term. The analysis quantifies the societal benefits in terms of economic, social, and environmental impacts derived from avoided emissions to facilitate the forward-looking assessment. The impacts are evaluated through a comparative analysis that measures the performance of the LT-LEDS scenario against the BAU scenario to provide valuable insights into the effectiveness of the policy portfolio in relation to government expenditure.

1. Economic empowerment: How a LT-LEDS can fuel sustainable economic growth

Benefits derived from the LT LEDs scenario includes positive impacts on GDP, sectoral growth in agriculture, industry and the service sector, with marginal change in hiring trends and negative impacts observed in the short-term for the agriculture and service sector.

Table 1. Net economic impacts for total GDP and value added by economic sector (Real 2016 billion PKR). The net impact captures the absolute change between the policy and BAU model scenarios.

	GDP	Agriculture	Industry	Services
2024-2029	714	192	138	346
2030-2039	8,289	2,290	1,402	4,166
2040-2050	23,986	6,116	3,881	12,742



Figure 8. Benefit-cost ratio derived from LT-LEDS on economic growth (above). Job creation benefit-cost in Jobs per Billion RLCU (below).

Direct economic impacts are primarily assessed in terms of the real gross domestic product (GDP), gross value added (GVA) and trends in hiring across the economic sectors in the model (Agriculture, Industry and Services). The net impact represents the difference between the policy and BAU model scenario in absolute terms. The cost-benefit ratio assesses the effectiveness of the LT-LEDS scenario relative to the resources invested, by dividing the net impact by the cumulative government expenditure over the preceding funding period (i.e. 2020-2029, 2030-2039, 2040-2050). Results are reported for 10-year periods: 2020's, 2030's and 2040's.

Table 2. Net impact on net hiring across economic sectors (thousand persons).

	Total	Agriculture	Industry	Services
2024-2029	-19,562	-489	6,079	-25,153
2030-2039	-61,537	58,171	-7,778	-111,930
2040-2050	54,063	24,028	16,261	13,774

For the LT LEDS scenario, the net impact on GDP grows progressively, with an increase of 714 billion PKR by 2030 and 23,986 billion PKR by 2050 (inflation-adjusted relative to 2016). This corresponds with a positive cost-benefit, such that 1 PKR contributes to GDP growth by a proportion 1.8 in 2030 and 4.4 by 2050. Majority of the economic growth is derived from the service sector, such that value added doubles relative to government expenditure by 2040, followed by marginal growth in the agriculture and industry sectors for which value-addition is more beneficial in the long-term (2050).

Conversely, trends in total net hiring show a negative impact in the short-term (2030 & 2040) before a positive impact is observed in the long-term (2050), such that one billion PKR spent between 2024-2030 results in loss of -19,562 jobs, but results in a gain of 54,063 per billion PKR spent by 2050. Net hiring by sector shows a shift in hiring from industry to agriculture in the short-term, with longer-term growth observed in the industry and services sector. For this reason, it is necessary to implement just transition incentives and provide reskilling initiatives to retain job-losses during the transition, particularly during the early phases of implementation of the LT-LEDS.

2. Social impacts of LT-LEDS integration

Social benefits derived from the implementation of a LT LEDs scenario under current model assumptions are mostly observed in terms of 'life expectancy,' 'managed water access,' and 'years of schooling' with marginal impacts

on access to services over the BAU scenario.

Social benefits are assessed in terms of key indicators relevant to the social context in Pakistan and with reference to key social themes identified in the global LT-LEDS agenda (IRENA, 2023), including indicators for poverty, access, and health. This includes the impacts on poverty, which is measured as the proportion of population below the lower to middle income line of US\$3.20 per person per day. Based on previous studies, poverty levels in Pakistan have particularly shown improvement, with a decline from 73.5 % to 35.5 % by 2018, below the lower-middle income line (World Bank, 2022). Though in this analysis, zero impact is observed over time under the LT-LEDS scenario over the BAU. Social indicators in terms of access and health similarly show a marginal change over the simulation period (2020-2050).

Table 3. Net impact between the BAU and LT-LEDS scenario for key social indicators (units: proportion change). Change in the average life expectancy and years of schooling are represented in units of years.

	Basic Healthcare	Electricity	Managed Water	Schooling	Poverty	Fertility	Life Expectancy
2024-2029	0	0	0	0	0	-0.01	0
2030-2039	0	0	0.01	0.01	0	-0.15	0.07
2040-2050	0.01	0	0.1	0.03	0	0	0.04

Access to basic healthcare shows a 1% increase in 2050. Access to water has been emphasized as a key challenge in Pakistan, though the LT-LEDS shows improvement in access to safely managed water, with an increase of 10% by 2050. Moreover, no net impact is observed for access to electricity. Based on recent household survey data, a large proportion of the population (~97%) currently has access to electricity (World Bank, 2022), though additional impact is needed to achieve universal electricity access. Lastly,

average life expectancy, a measure of community health, shows a marginal impact with an increase in 0.07 and 0.04 years in 2040 and 2050 respectively, owing to lower projected mortality in the long-term. The minor social impacts observed for the LT-LEDS scenario highlights the need for more direct social policy expenditure to be implemented in synergy with LT-LEDS to achieve higher social gains, this can include dedicated policy towards healthcare and education

3. Environmental impacts from LT LEDs implementation

Environmental benefits arising from the LT-LEDS scenario are mainly observed as a result in a reduction of emissions from fossil fuel sources owing to a rapid decarbonization of the transport sector and higher uptake in renewable energy consumption. Positive impacts on biodiversity are observed with a minor increase in the 'Red List index' and lastly, impacts from observed trends in water withdrawal only show a reduction in withdrawal in the long-term.

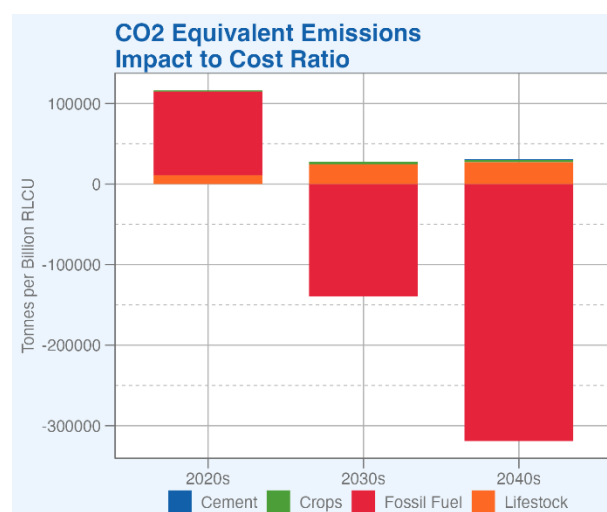


Figure 9. Cost-benefit ratio in (tonnes of CO₂eq/billion RLCU) for GHG emissions stacked by contributions from fossil fuel, livestock, crops and cement.

In Pakistan, emissions are largely driven by agriculture, forestry and land use; and

energy, accounting for 46% and 45% of total national emissions, respectively (World Bank, 2022). Moreover, energy consumption by source, as reported in 2019-2020, is predominantly from fossil fuels with 31% oil, 31% Gas and 19% coal (World Bank, 2022). As a priority of the LT-LEDS policy and in line with global climate commitments, a reduction in total greenhouse emissions remains a key target (IRENA, 2023 & UNFCCC, 2023). In the iSDG-Pakistan, GHG emissions are disaggregated by source: fossil fuels, livestock, crops, and cement production (Table 4).

Table 4. Net impact on greenhouse gas (GHG) emissions, disaggregated by source (units: thousand tonnes in CO₂eq).

	Total	Fossil fuel	Livestock	Crops	Cement
2024-2029	44, 864	40,048	4,207	601	8
2030-2039	-239,520	-299,298	52,725	6,582	469
2040-2050	-180,656	-197,456	14,703	1,563	531

Under the LT-LEDS scenario, the impact from total greenhouse gas emissions (in CO₂eq tonnes) increases relative to the BAU scenario in 2030 by 44,864K tonnes, reduces by 239,520K tonnes by 2040, and a reduction of 180,656 between 2040 and 2050 (Table 4). In terms of the benefit relative to the government costs, an increase in around 116 000 tonnes total GHG emissions can be expected per 1 billion PKR spent by 2030. Though, after 2030 benefits in a reduction in emissions are observed, such that 1 billion PKR invested in LT-LEDS between 2030 and 2040 results in a reduction 112,000 tonnes of total GHG emissions. Similarly, in 2050, a reduction of 33,000 tonnes of CO₂ equivalent is observed per billion PKR invested by 2050. The largest reduction in total GHG emissions is from a decrease in emissions for fossil fuel consumption owing to an increase in the use of renewable energy sources. Moreover, the largest

benefits in terms of total emissions relative to LT-LEDS investment is observed between 2030-2040 with a lower rate of decrease in the reduction of emissions beyond 2040. This is due to increases in electricity demands from electrification of the transport sector. As electricity demand increases rapidly after 2030 the additional demand is met by additional fossil fuel electricity generation capacity. Though not directly captured in the model, the reduction in emissions is expected to result in cleaner, better quality air with positive impacts on human health, particularly in urban areas.

Table 5. Net impacts for key environmental indicators. Units for water withdrawal are represented in million cubic meters (CM) whereas the proportion of renewables in the final energy consumption and the red list index show the percentage change.

	Renewable energy consumption proportion	Red list index	Total water withdrawal
2024-2029	0.00	0.02	151
2030-2039	0.31	0.10	6,299
2040-2050	0.20	0.14	3,895

As a drought-stricken country, patterns of water consumption are integral to measure environmental impacts. Though under the LT-LEDS scenario, trends in water withdrawal continue, with a delayed reduction only observed between 2040 and 2050 (Table 5). Hence, it is recommended to integrate water-wise management strategies into the LT-LEDS to enable a reduction in water withdrawal in the long-term.

Lastly, the red-list index indicator provides an aggregate measure for the state of

biodiversity in the country. Under the LT LEDs scenario the net impacts in terms on the red list index increase, reflecting a positive change in biodiversity by 10% and 14% by 2040 and

2050, respectively. This highlights the importance of implementing conservation measures to enhance environmental benefits from the LT-LEDS. This further supports the conservation priority areas outlined in Pakistan's NDCs (Government of Pakistan, 2021) which include reforestation – such as the 'Ten Billion Tree Tsunami', as well as increasing protected areas (Pakistan, 2021). Conservation directed migration and adaptation measures can have farther reaching impacts biodiversity and human health.

4. Prospects for LT-LEDS CBA analysis

Prospects to strengthen the findings of the cost-benefit analysis can include performing an optimisation to assess the distribution of expenditure across sectors to maximize the impact on specific indicators. Additionally, normalising the societal impacts, to obtain cost benefit ratios can entail monetizing the outputs in terms of market and non-market value (e.g. impact of CO₂ emission reduction using carbon pricing), though, this is more suited to project-specific investment assessments as opposed to broader, macro assessments to measure societal gain (Mechler, 2008). Lastly, the CBA does not address the distribution and inclusivity of benefits across members of society, though the elements towards a just transition are addressed in the previous chapter.

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Annex

Method

- The evaluation of the benefits of the LT LEDs is assessed for two scenarios: the Baseline (Business-as-usual) scenario, representing a status quo with no changes in government expenditure behavior, and the policy (LT-LEDS) scenario, which involves strategic government expenditure to facilitate the LT LEDs.
- Inputs encompass government expenditure, anticipated electricity generation capacity until 2030, and electric vehicle adoption targets, while outputs denote the impacts on societal indicators. Depending on the unit values, benefits may have positive or negative impacts. E.g. a negative GHG emission is a benefit, due to lower emissions, whereas a positive GDP value is also a benefit.
- Impacts are assessed for various key development indicators and selected with relevance to LT-LEDS strategies as identified in IRENA, 2023 and UNFCCC, 2023 synthesis reports, but also with relevance to the country context as represented in the iSDG-Pakistan model (Table 6).

- The benefit of the LT-LEDS scenario is evaluated against the performance of the BAU scenario.
- A cost-effectiveness analysis assesses the effectiveness of the LT-LEDS scenario in achieving its objectives relative to the resources invested. This entails dividing the change in indicators (e.g., reduction in greenhouse gas emissions, improvement in air quality) by the total government costs associated with implementing the LT-LEDS scenario.

Table 6. List of key indicators assessed to measure the impacts of the LT-LEDS scenario.

	Indicator
Economic	• Real GDP • Total Net Hiring
Social	• Population below national poverty line • Life Expectancy • Fertility rate • Access to electricity • Access to water • Access to basic healthcare • Years of schooling
Environmental	• Renewables share in total energy consumption • Total Green House Gas Emissions • Total water withdrawal • Red list index

Implications and Learnings of the LT-LEDS Assessment

Implications and Learnings of the LT-LEDS Assessment

Under the assumptions of the LT-LEDS scenario, the impact in Pakistan is projected to contribute substantially to the decoupling of growth and emissions while also yielding significant economic growth by 2050. Growth is seen in all economic sectors, however the services sector grows much more rapidly than others with a cumulative contribution of approximately 17 trillion real 2016 PKR from 2024 to 2050.

The adoption of green activities fosters the creation of approximately 150,000 new jobs by 2050. However, the shift towards greener economies also presents medium-term challenges, including cumulative employment reductions until the 2040's, where all sectors see employment growth as the economy adapts to increasing efficiencies and reliance on imports.

The strategy will also bring about modest social benefits over the business-as-usual (BAU) scenario, such as improvements in life expectancy and managed water access, although these gains are relatively marginal. To maximize the societal benefits of LT-LEDS, it is important to optimize expenditure distribution between interventions.

Furthermore, aligning workforce skills with the emerging green job market is essential for a just transition, as evidenced by the positive impact on the Just Transition Index (JTI) of approximately 2.5% from 2024 to 2050 over the BAU and the observed sectoral shifts in employment.

Decoupling and Decarbonization

In addition to economic shifts, the LT-LEDS is set to drive significant environmental gains, with a cumulative reduction of 1.6 billion tonnes of greenhouse gas emissions by 2050 and a 19 percent annual reduction

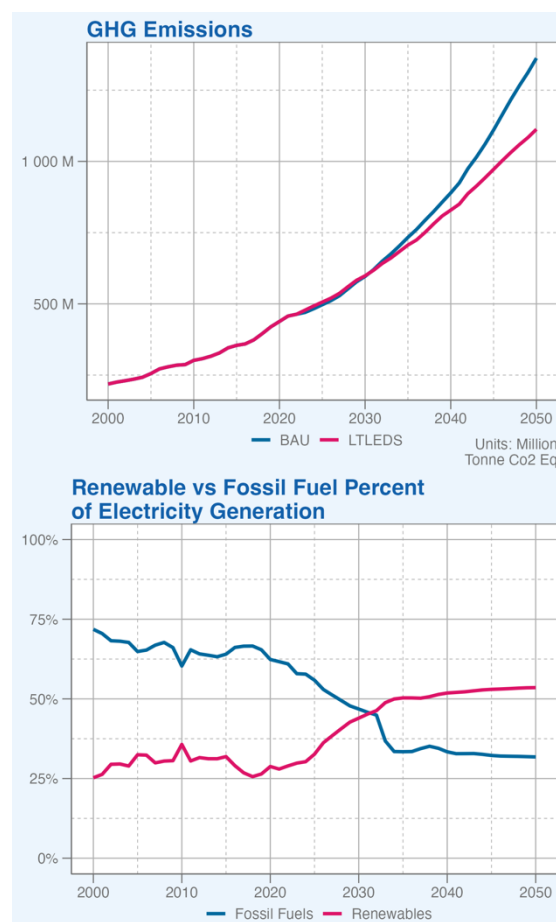


Figure 1: 1a. GHG Emissions in the BAU vs the LT-LEDS scenarios; Figure 1b. Proportions of electricity generation by type of generation capacity.

in GHG emissions by the same year (Figure 1a).

The emissions reduction is largely driven by the decarbonization of the transportation sector. The electric vehicle (EV) adoptions targets of the LT-LEDS leads to a large reduction of emissions over the BAU of ~2.4 billion tonnes of CO₂ equivalent (Figure 3b). This impact is created by EVs overtaking fossil fuel vehicles (FFV) by 2043 and make up nearly double by 2050. FFVs peak in 2033 and return to 2010 levels by 2050.

The decarbonization of the transport sector contributes directly to substantial decreases in emissions in Pakistan, but also created counterproductive effects limiting emissions reductions downstream. From 2024 to 2035, a significant drop is seen in the percent of electricity generated

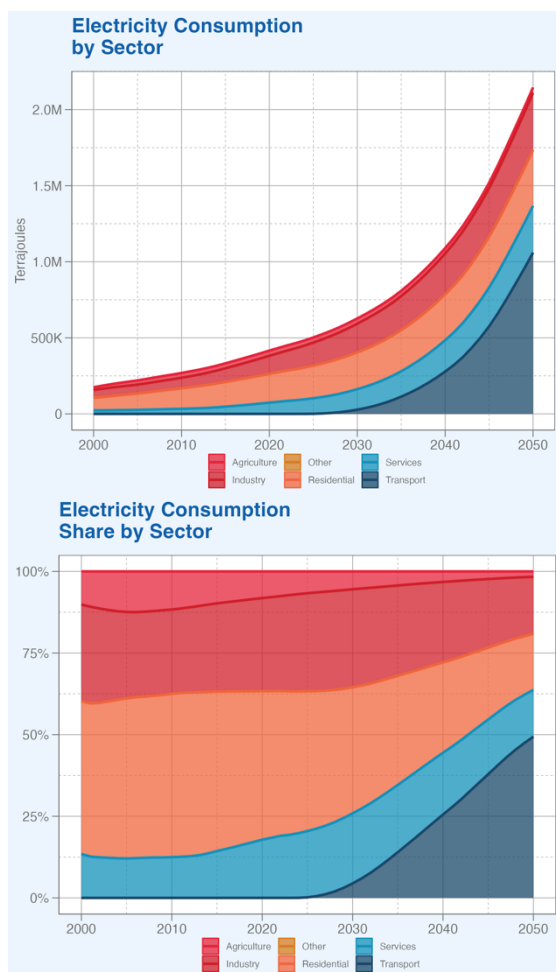


Figure 2: 2a. Total electricity consumption by activity; 2b. Electricity consumption share by activity

by fossil fuels (Figure 1a). However, this transition towards renewable sources of electricity generation slow following 2035 and remains largely static.

The stagnation of the transition towards renewable sources of electricity generation is driven by the rapidly expanding electricity demand driven by the transport sectors electrification (Figure 2a and 2b). This rapid growth in electricity demand puts pressure on existing capacity generation and leads to continued development and use of fossil fuel-based electricity generation systems, particularly natural gas and coal (Figure 3a).

This is one significant driver leading to increases in emissions in other activities compared to the BAU (Figure 3b). Additional considerations, particularly to mitigate the over reliance on electrification,

can include integrating green hydrogen and associated fuel-derivates into the energy mix, particularly for use in the transport and hard-to abate industrial sectors (Millennium Institute, 2022).

Areas for Greater Impact

Increasing the already substantial reduction of emissions seen in the LT-LEDS scenario can be approached from multiple angles. Supporting efficiency standards in transportation systems and buildings, supporting phasing out of fuel inefficient vehicles, electrification of buildings, strengthening industry emissions standards, nature-based solutions, and carbon sequestration are all potential areas for analysis to refine emissions reduction over the future.

Improving energy efficiency standards of transportation systems, commercial or private vehicles, and public transit, can reduce GHG emissions by decreasing fuel consumption over the long-term. This approach can be supplemented by supporting the replacement of fuel-inefficient transportation systems to accelerate the transition to lower-emission alternatives through subsidies and/or taxes on new vehicles. Updating of the transportation system can also stimulate economic growth by boosting demand for clean transportation technologies, particularly if domestically produced, and enhancing air quality.

Further, increasing energy efficiency of buildings by enhancing insulation, upgrading heating or cooling systems, and improving appliance efficiency through retrofitting and in new developments can contribute to a reduction in energy consumption and any associated GHG emissions created as a result. This approach will pay dividends long into the future, as the stress on electricity generation due to electrification will decrease. Decreasing the energy usage will help to off-set any unanticipated

demand due that may extend the life of fossil fuel based electricity generation capacity out of necessity. Additionally, investment in increased building efficiency will reduce energy costs and job creation in green construction and energy efficiency services.

Supporting electrification of commercial, industrial, and residential buildings will further reduce GHG emissions; however, only if paired with the replacement of fossil fuel based electricity generation capacity. Downstream, electrification promotes the growth of energy efficient industry, creates jobs, and increasing national energy security, while also decreasing pollution, which will improve public health outcomes. This approach must also be paired with the increased development of renewable energy sources to deliver reductions, otherwise emissions will only be generated further downstream from the consumption.

Strengthening emission standards in industries will encourage the adoption of cleaner technologies and processes. As seen in Figure 3b, due to greater economic growth in the LT-LEDS scenario, industry emissions increase over the baseline scenario. In this case, emissions per unit of output remains stable over the scenarios, thus the increase in industrial activity contributes greater emissions in the policy scenario. This policy can also promote innovation in low-emission manufacturing and industrial efficiency. Strengthened standards can help industries align with international climate commitments, enhancing national competitiveness in global markets, while also improving air quality and public health.

Nature based solutions, such as expanding forests through afforestation, restoring degraded lands, and implementing carbon-capturing agricultural practices will contribute to GHG reduction by increasing natural carbon sinks. Similarly, as seen from industry emissions in the LT-LEDS scenario, these agricultural practices can help to ameliorate the increased emissions

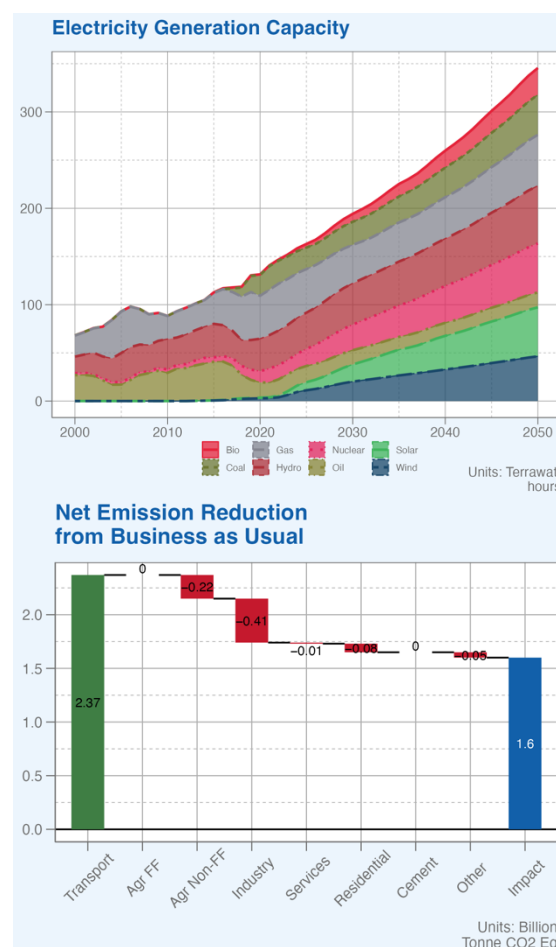


Figure 3: 3a. Electricity generation capacity by energy type. 3b. Emission reduction impact by emission source in LT-LEDS scenario

seen from agriculture (Figure 3b). These practices will not only support emission reduction but also enhance biodiversity, soil health, and water resources. Afforestation supports rural development, creates jobs in land management, and fosters ecosystem resilience, while simultaneously reducing vulnerability to climate impacts.

Into the future, promoting carbon sequestration technologies like direct air capture and enhanced mineralization offers a high-potential solution for removing emissions from the atmosphere, and thus offsetting any emissions generated. While these technologies are energy-intensive and require significant investment, they can play a critical role in achieving decarbonization and decoupling development from emissions. In the long

term. Advancing carbon removal technologies can further position a nation as a leader in climate innovation, attracting global investments and contributing to the global carbon reduction effort, while also stimulating growth in the technology sector.

Future Efforts

As seen in the LT-LEDS results, electrification and strengthening of efficiency and emissions standards in transport and residential, commercial, and industry, as well as rapid growth of renewable electricity generation capacity can greatly reduce emissions. However, in order to reinforce impacts of the LT-LEDS in decoupling productivity and emissions, the, future electricity generation capacity must take into account the anticipated EV adoption and other electrification efforts down-stream effects on electricity demand.

Building this consideration into electricity capacity generation efforts will ensure electricity demands are satisfied by renewable sources, rather than forcing non-renewable sources to remain active beyond anticipated timelines. Additionally, policies targeting nature-based emission

reduction or sequestration practices as well as technological carbon sequestration can all further reinforce the returns seen in the LT-LEDS scenario.

Furthermore, while there are modest improvements in life expectancy and managed water access. The results in the Just Transition Index of 2.5% increase over the BAU and limited progress on social factors emphasizes the need for greater evaluation of social oriented expenditure distribution and enhanced conservation measures to maximize societal benefits.

Beyond the results of this assessment, additional refinement can be made in future assessment efforts to improve the expenditure categorization mapping to interventions and unit costs of policy options as well as to explicitly evaluate the potential impacts of policy options individually and in conjunction. This will improve the accuracy of the scenario design and as well as the analytical power of the simulation results to support identifying areas where greater returns can be found.

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Technical Annexes

The iSDG Model

The integrated Sustainable Development Goals (iSDG) model is a System Dynamics based tool that has been designed to support national development planning. The iSDG model is formulated as a system of ordinary differential equations, and includes approximately 3,000 variables organized into 30 sectors. The iSDG's sectors cover key social, economic, and environmental development issues, and are dynamically linked in order to represent the complex, interconnected relationships that drive sustainable development.

The iSDG model evolved from the Millennium Institute's (MI) experience in developing and applying models for evaluating policy impact on sustainable development. Notably, the iSDG builds upon the Threshold 21 model, which focused on assessing policy impact on the Millennium Development Goals. These models have been developed over the past 35 years as tools to support policy development (Pedercini et al., 2018).

The MI has applied these models in over 40 countries, and has used the tool to develop plans for national development, green economy, and sustainable agriculture. The models are built using the System Dynamics (SD) methodology, which excels at deconstructing and analyzing complex socio-economic environments and policy systems (Stermann, 2000). This method of simulation aids in garnering insight into complex inter-relationships (Davis et al., 2007). SD has a long history of application for analyzing social, environmental, and economic issues. These characteristics make SD a methodology well suited to exploring policies in the complex, interconnected system that is sustainable development of a country.

The iSDG model structure includes all 17 SDGs and 78 SDG indicators.² The model includes 30 social, economic, and

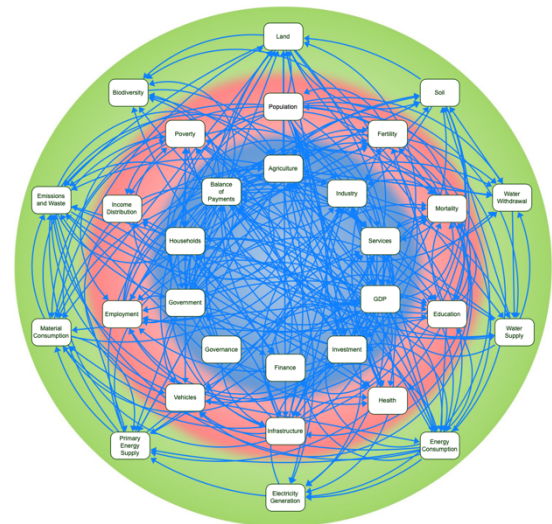


Figure 1. Overview diagram of the iSDG model including Economic (Blue), Social (Red), and Environmental (Green) sub-models

environmental modules (Figure 1). The sectors of the iSDG are categorized into environmental (green), social (red) and economic (blue) modules.

Each module operates as a sub-model, and includes the factors which influence SDGs within the sector. The arrows connecting the sectors in figure 1 show how the model also integrates the sectors by modeling the cross-sectoral impacts. As the model simulates, the modules interact with each other based on the calculations done within the module. This interaction between modules enables the integration of cross-sectoral effects, which are a necessity when assessing policies for sustainable development.

Calibration

The iSDG relies on an extensive dataset to customize the model to the local context. This dataset is collated and constructed from a range of databases managed by international organizations, academic literature, and, in some cases, supplemented with data sourced from local government. Following preparation of the national database, the model is calibrated to historical data to build the explanatory power of the model.

Throughout the calibration process, partial models are created to segment sections of the iSDG into smaller components using exogenous data to overwrite equations (Homer, 2012). These partial models isolate the feedback effects, and ensure the model is not over fit during calibration. Once partial models are created, a payoff variable is identified and a partial-model including only the structure directly impacting the payoff variable's calculation is created.

Next, optimization algorithms search across the defined thresholds to estimate each parameter that impacts the relationships of the variables. The goal of the search to minimize error between the simulation and historical data, and is achieved by simulating the partial-model with combinations of each parameter being estimated.

In the case where the optimization space may be less complex, then the *Powell* algorithm is used for efficiency (Powell, 2009). However, Powell is a local search technique, and may not identify all optima or global optima. In more complex cases, *Differential Evolution* is used to explore parameters more completely (Price, 2005).

For example, to calibrate total fertility rate, the payoff variable, to historical performance, then the variables of disposable income, under five mortality, and average years of schooling will be over written with historical data. Then, parameters for calculating the effects of said variables would be included in the optimization.

Once partial-model calibration has complete, the partial-models are joined to endogenize the effects of the sectors on the behavior of the model. This is achieved by enabling the calculated inputs from other sectors, rather than using the historical data that isolated the partial-models.

Following endogenization, the calibration performance of the whole-model simulation

during the historical period is reviewed against historical performance. This is achieved by calculating standard statistics of fit. The statistics enable the identification of the causes of residual error when the model simulation is compared with historical data.

Explanatory Power

Five statistics are used to measure goodness-of-fit: *R-Squared*, *Root Mean Square Percent Error*, and the *Theil Statistics* for error decomposition.

R-Squared, R^2 or the *coefficient of determination*, in this case, compares the correlation between the simulated series and the historical series, and *explains*, how much of the change in the dependent variable (historical) is explained by the independent variable (simulation). The *Root Mean Square Percent Error* (RMSPE) builds on the previous statistic, in that it indicates the percent error between the historical and simulated values. These variable help to indicate the overall performance of the model to replicate past behavior.

Identifying size of error is necessary to measure goodness-of-fit, however the origin of that error, is also important to identify how it impacts the interpretation of the model. The three *Theil Inequality Statistics*; *Bias* U^M , *Variation* U^S , and *Co-variation* U^C , enable unpacking the source of the error (Theil, 1966). This approach has long been a best practice within the field of Econometrics and System Dynamics in order to determine error based on the purpose of the model (Sterman, 1984).

Bias describes the average difference of the simulation and history. If error is large and a majority of error lies in bias, it can indicate a systematic error to the model. *Variation* indicates the scale of variance around the mean of the time series, and indicates how effectively the model tracks cycles or trends in the data. While, error in

Co-variation measures how well the simulation matches trends point-by-point. Generally, if total error is low and observed error is concentrated in *Variation* and *Co-variation*, then the model tracks long term trends effectively, assuming a low *Bias*.

The use of these statistics come with caveats that help interpreting their values. A high R-squared and a low residual error is not always the main purpose of a model application. Structural models, like the iSDG and other System Dynamics models, main purpose is to develop reliable and transparent assumptions about how a system interacts in order to enable deriving useful inferences from the model structure about how policies may impact goals, rather than predicting a future outcome.

Additionally, "goodness-of-fit" is defined relative to the model's purpose (Forrester, 1961). Specifically, the iSDG Model's purpose is to analyze medium to long-term development issues at the national level in order to support analysts and policymakers understanding the consequences of current and alternative policy choices. For this reason, short-term cycles are not always replicated by the model structure, while replicating the long-term underlying trend of the historical series is the focus of the calibration.

Interface

The iSDG utilizes the iSee Systems Stella Architect software for developing and using the model. This software is a System Dynamics modelling tool that allows creation of system diagrams that can be simulated over time. The Stella software interface enables the development models using a graphical interface that enforces the rules and mathematical rigor of the methodology. Figure 1 shows an overview of the iSDG, which illustrates the modules of the model.

Each module is a sub-model that contains the variables and equations relevant to the module. The arrows between the modules indicate that one or more variables from a module influence variables in the connected module. The breadth of connections between the modules is what enables the interrelations between drivers of development, and makes the iSDG unique.

Within the modules, we see the diagramming language used to express the model at the visual and mathematical level. This is diagramming language and mathematical framework is explained further in the System Dynamics Technical Annex. Figure 2 shows the structure of the Firms module, which encompasses the factors driving firm output in the agriculture, industry, and services sectors.

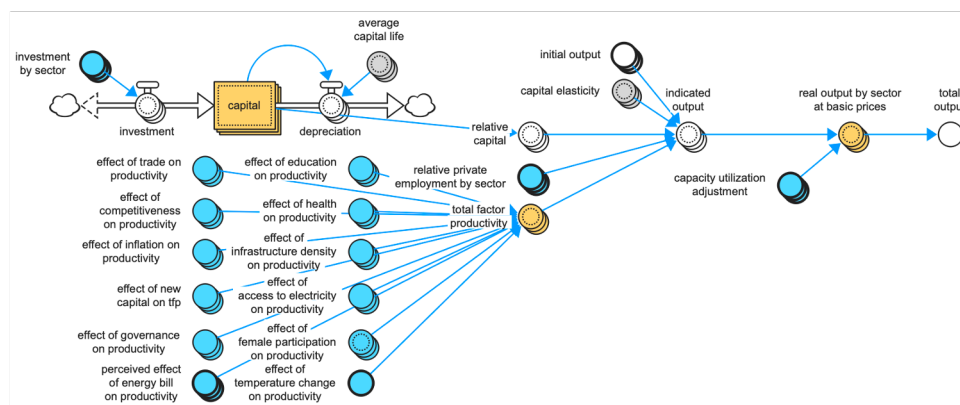


Figure 2. Overview diagram of the Firms Module

The iSDG can be navigated from the top level of the model, the home location, shown in Figure 3a, to each individual module within the model. Within the modules, the variables are selected to display both their equations and their simulation results, as shown in Figure 3b.

In Figure 3a, the configuration of the model is visible. This includes the simulation time horizon, in this case from 2000 until 2050. The time step of the model is also set here, which is the number of times the model is solved for each unit of time. In this case, the model is solved 4 times for each year simulated, which provides annualized values for each quarter.

Figure 3b shows the interface of the model when navigating and selecting a variable. The simulation results are viewable using a behavior over time graph as well as a table reporting the values for each time step. The mathematics underlying the model solving

is further detailed in the System Dynamics Method technical annex.

The visual diagramming language used in the Stella Architect software that represents the mathematical underpinnings of the model makes the iSDG transparent to non-technical as well as technical users. Model structures, variables, equations and simulation behavior is directly investigable, enabling users to unpack the drivers policies under analysis. Further, this approach gives the iSDG the unique capability to trace the impacts of policy changes throughout the model from the direct effects of budgetary allocations to the indirect effects further downstream from the policy. This allows the analysis of the integrated, multi-dimensional nature of national development.

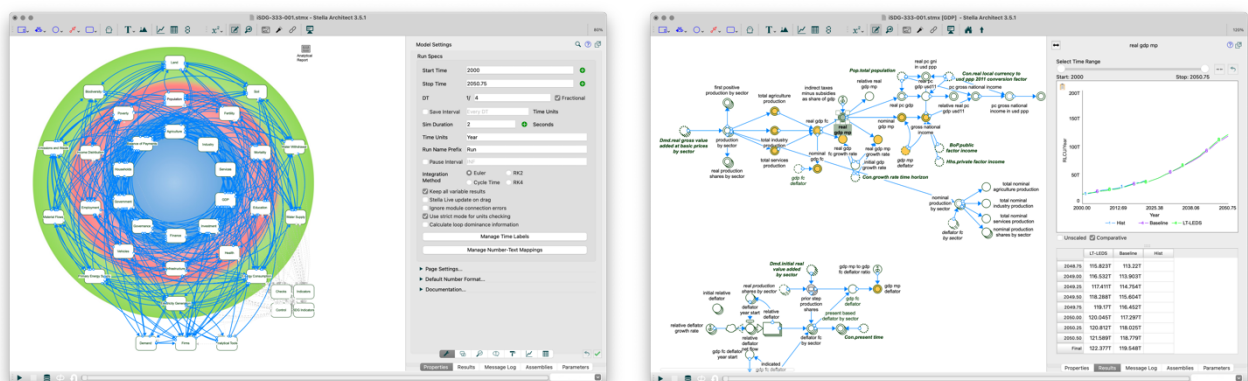


Figure 3: 3a. Software interface at top-level of model, 3b. Module interface and simulation results

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System Dynamics Method

The System Dynamics (SD) methodology is a quantitative modeling approach that enables understanding of the structure and dynamics of complex systems. More practically, the method is used to build formal computer simulations of complex systems, and use them to test and design effective policies. The method achieves this by mathematically representing how the structure of systems generates the behavior experienced in the past, and thus, can project, how the system will react to policy changes in the future. SD simulations are calculated in continuous time, over a specified simulation period, and the equations of the model are constructed as a system of differential equations, where time is the independent variable.

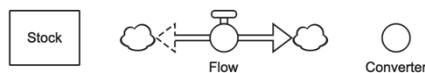


Figure 1. SD Building Blocks

SD software uses visual diagramming in order to define the mathematical equations of the model. The building blocks of the visual diagram are stocks, flows, converters, and arrows (Figure 1). Each building block indicates a particular mathematical behavior. Stocks are accumulations of some material or information and describe the state of the system. Stocks also create the information which is used in the model for actions and decision making. Some examples of stocks are: population in a city, vehicles in country, or capital in the economy. Flows, on the other hand, are the rates over time that cause stocks to change in value, for instance: birth and death rates, purchasing or depreciation of vehicles, and investment or depreciation of capital.

The final building block of SD are converter variables, which are intermediate variables that convert information from one set of stocks and flows to other sets of stocks and

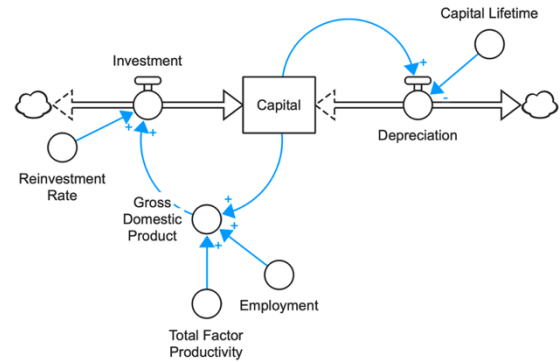


Figure 2. Economic Model Example

flows. For instance, this may be the influence of the stock of healthcare facilities on the access to healthcare which impacts fertility or mortality, the level of disposable income on purchasing new vehicles or maintaining existing vehicles, or the return on investment of economic activities on proclivity to invest in certain economic sectors. The final example will be used to illustrate a simple model and the mathematics behind them.

In the diagram above, a simplistic economic model shows the increase of capital through investment, the change of GDP due to Capital, as well as the feedback of GDP changes in driving investment (Figure 2). One additional building block has been added, the arrows connecting variables. The arrow indicates direct causality moving in the direction of the point of arrow, and in this case would mean that capital in the economy directly causes the gross domestic product.

Mathematically, this means that the variable at the end of the arrow must use the variable at the start of the arrow in its equation. Further, the arrows indicate the direction of causality, that being a positive causal relationship or a negative causal relationship. In a positive relationship, the variables values will move in the same direction, while for a negative relationship, the values will move in the opposite direction.

For example, in the positive relationship between capital and GDP, if capital goes up, ceteris paribus, then GDP will also go

up, however if capital goes down, then GDP will also decrease. While in the negative relationship between capital lifetime and depreciation indicates that if capital lifetime increases, then depreciation decreases, while if capital lifetime decreases, then the rate of depreciation will increase. The direction of the relationship is dependent upon the mathematics used to specify the equation of the variables.

In this simple model, the stock of capital in the economy is increased through investment and decreased through depreciation. In this example, the stock accumulates capital within the economy, and this is mathematically represented as the integration of the investment and depreciation flows. Essentially, the net flow, or the difference of the investment and depreciation into the capital stock is the rate of change of the capital stock per year. Based on this explanation, it can be represented mathematically as an integral as follows; where s is the time step anywhere between the initial time (t_0) and the end time(t):

$$Capital(t) = \int_{t_0}^t [Investment(s) - Depreciation(s)]dt + Capital(t_0)$$

Different from the mathematics of the stocks and flows, converters are not integrated, rather they are solved instantaneously using basic algebraic relationships. Additionally, converters can take on specific functions in a model in order to holds values for constants or define external inputs to the model. In the example model above, GDP is a converter and could be assumed to use a Cobb-Douglas type production function where:

$$Y = f(A, K, L)$$

In regards to the solving of SD models, the order of operations is important in understanding how the mathematics comes together to calculate variables in continuous time.

In the first step of the simulation the mode is initialized. Initialization is done by

calculating the initial values of all stocks for the start time of the simulation, which are given as inputs, and then calculating the initial values of flows and converters are based on the initial values of the stocks at the simulation start time. In the second step, the values of stocks at the preceding time are used to calculate the values of the flows and converters at the next time step. Then, the flows are integrated in order to calculate the stocks changes over the interval of DT for the value of the stocks at the next time step. Last, the simulation time is incremented by DT and the second step continues in a loop for each following DT until simulations end time.

The SD method is unique in the field of modeling in its approach and the nature of the method as described above makes SD particularly useful for describing causality visually and mathematically, tracing causality across models to identify why variables change, uncovering how structure generates behavior in the system, and testing policies in order to assess impact on priorities and goals. For further information, please refer to *Business dynamics: Systems thinking and modeling for a complex world* by John D. Sterman.

Of course, SD is one tool in the toolkit for understanding a complex system, and provides one perspective that can be used to analyze and plan, however different methods have different properties and are useful for different purposes, and in many cases can be integrated in wider processes to develop more sophisticated solutions.

Selected Results: Policy Scenario

Economic KPIs																											
Variable	Units	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Real Gross Domestic Product at Market Price	Real 2016 LCU	42,574B	44,360B	46,480B	49,236B	51,890B	53,844B	56,309B	59,222B	61,634B	64,389B	67,330B	69,971B	73,117B	76,006B	79,079B	82,092B	85,399B	90,151B	93,609B	97,540B	102,009B	106,676B	110,528B	113,670B	116,532B	120,045B
Real Agriculture Gross Value Added	Real 2016 LCU	10,121B	10,465B	10,905B	11,567B	12,177B	12,524B	13,047B	13,717B	14,194B	14,776B	15,400B	15,905B	16,568B	17,118B	17,709B	18,251B	18,863B	19,932B	20,513B	21,205B	21,991B	22,784B	23,487B	24,091B	24,629B	25,365B
Real Industry Gross Value Added	Real 2016 LCU	6,915B	7,220B	7,579B	8,015B	8,455B	8,827B	9,257B	9,740B	10,174B	10,652B	11,153B	11,627B	12,164B	12,691B	13,255B	13,830B	14,452B	15,256B	15,946B	16,720B	17,605B	18,546B	19,298B	19,906B	20,478B	21,139B
Real Services Gross Value Added	Real 2016 LCU	23,327B	24,371B	25,582B	27,097B	28,562B	29,696B	31,080B	32,689B	34,064B	35,617B	37,280B	38,805B	40,587B	42,249B	44,007B	45,747B	47,648B	50,281B	52,287B	54,548B	57,115B	59,805B	62,002B	63,769B	65,371B	67,307B
Total Real Imports	Real 2016 LCU	10,652B	11,373B	12,163B	13,037B	13,833B	14,448B	15,200B	16,016B	16,696B	17,469B	18,281B	19,066B	19,961B	20,779B	21,652B	22,511B	23,493B	24,814B	25,795B	26,938B	28,215B	29,578B	30,749B	31,771B	32,725B	33,839B
Total Real Exports	Real 2016 LCU	7,688B	8,166B	8,678B	9,291B	9,874B	10,314B	10,845B	11,458B	11,972B	12,551B	13,165B	13,721B	14,377B	14,983B	15,628B	16,262B	16,956B	17,940B	18,670B	19,498B	20,438B	21,424B	22,251B	22,938B	23,571B	24,334B
Real Total Investment	Real 2016 LCU	5,503B	5,958B	6,473B	6,987B	7,459B	7,784B	8,192B	8,603B	8,957B	9,385B	9,911B	10,404B	10,999B	11,411B	11,842B	12,216B	12,659B	13,258B	13,606B	14,074B	14,602B	15,165B	15,464B	15,615B	15,612B	15,719B
Total Net Hiring	People/Year	1,960K	1,994K	2,006K	1,940K	1,995K	1,996K	1,937K	1,812K	1,774K	1,755K	1,705K	1,700K	1,690K	1,701K	1,767K	1,830K	1,881K	1,835K	1,915K	1,994K	2,054K	2,111K	2,076K	2,118K	2,182K	2,259K
Agriculture Net Hiring	People/Year	722K	686K	683K	727K	733K	615K	580K	572K	500K	481K	471K	426K	437K	397K	386K	363K	367K	464K	408K	402K	409K	407K	377K	360K	345K	394K
Industry Net Hiring	People/Year	526K	541K	561K	593K	636K	722K	712K	688K	707K	684K	669K	699K	699K	775K	816K	865K	884K	848K	942K	975K	995K	1,030K	1,129K	1,204K	1,268K	1,245K
Services Net Hiring	People/Year	712K	767K	762K	620K	626K	658K	645K	551K	566K	591K	565K	574K	554K	529K	565K	602K	630K	523K	564K	618K	650K	675K	570K	555K	569K	620K

Social KPIs																											
Variable	Units	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Total Population	People	238,150 K	242,450 K	246,837 K	251,322 K	255,900 K	260,571 K	265,357 K	270,259 K	275,262 K	280,367 K	285,545 K	290,749 K	295,970 K	301,195 K	306,476 K	311,800 K	317,156 K	322,538 K	327,921 K	333,310 K	338,700 K	344,092 K	349,489 K	354,897 K	360,324 K	365,787 K
Female Population	People	117,719 K	119,912 K	122,149 K	124,434 K	126,766 K	129,144 K	131,581 K	134,074 K	136,619 K	139,216 K	141,849 K	144,497 K	147,155 K	149,817 K	152,507 K	155,220 K	157,950 K	160,694 K	163,439 K	166,188 K	168,939 K	171,692 K	174,448 K	177,211 K	179,985 K	182,777 K
Male Population	People	120,431 K	122,538 K	124,689 K	126,888 K	129,134 K	131,427 K	133,777 K	136,185 K	138,643 K	141,151 K	143,695 K	146,251 K	148,814 K	151,378 K	153,969 K	156,580 K	159,206 K	161,844 K	164,482 K	167,121 K	169,761 K	172,400 K	175,041 K	177,686 K	180,339 K	183,010 K
Total Births	People/Year	6,166K	6,288K	6,418K	6,557K	6,697K	6,851K	7,012K	7,166K	7,313K	7,447K	7,529K	7,586K	7,628K	7,710K	7,804K	7,883K	7,951K	8,010K	8,063K	8,114K	8,166K	8,220K	8,281K	8,351K	8,432K	8,527K
Total Deaths	People/Year	1,739K	1,776K	1,813K	1,857K	1,908K	1,950K	1,992K	2,041K	2,083K	2,125K	2,167K	2,201K	2,241K	2,278K	2,319K	2,360K	2,393K	2,445K	2,488K	2,532K	2,579K	2,626K	2,674K	2,723K	2,769K	2,822K
Total Fertility Rate	Proportion	3.51	3.50	3.48	3.47	3.45	3.44	3.43	3.42	3.41	3.39	3.35	3.31	3.28	3.26	3.26	3.26	3.26	3.25	3.25	3.25	3.25	3.2471	3.2455	3.2439	3.2424	3.2409
Average Life Expectancy	Years	67.34	67.45	67.57	67.71	67.82	67.88	67.99	68.12	68.22	68.35	68.50	68.64	68.80	68.95	69.10	69.24	69.38	69.55	69.65	69.77	69.89	69.9919	70.0935	70.1927	70.2887	70.3959
Female Life Expectancy	Years	70.04	70.17	70.30	70.46	70.58	70.66	70.78	70.92	71.04	71.20	71.37	71.53	71.72	71.89	72.06	72.22	72.38	72.57	72.69	72.82	72.95	73.0635	73.1753	73.2854	73.3940	73.5147
Male Life Expectancy	Years	64.71	64.79	64.89	65.02	65.11	65.15	65.24	65.35	65.43	65.54	65.67	65.78	65.92	66.04	66.16	66.28	66.40	66.55	66.63	66.74	66.84	66.9329	67.0221	67.1083	67.1894	67.2811

Environmental KPIs																											
Variable	Units	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Proportion of Renewables in Total Final Energy Consumption	Proportion	0.39	0.39	0.39	0.38	0.38	0.38	0.37	0.37	0.38	0.39	0.39	0.39	0.38	0.39	0.40	0.40	0.40	0.41	0.41	0.42	0.43	0.43	0.44	0.45	0.46	0.47
Total Green House Gas Emissions	Tonne/Year CO2 Eq	506,473K	519,864K	536,374K	559,307K	581,480K	597,038K	616,409K	639,801K	662,558K	689,343K	713,613K	731,412K	757,908K	786,198K	812,521K	832,658K	853,686K	890,080K	915,841K	943,771K	973,147K	1,002,800K	1,031,025K	1,057,416K	1,081,560K	1,109,968K
Agriculture Fossil Fuel GhG Emissions	Tonne/Year CO2 Eq	10K	8K	7K	6K	6K	6K	7K	7K	7K	7K	7K	7K	7K	7K	7K	7K	7K	7K	7K	7K	7K	7K	7K	7K	7K	7K
Agriculture Non-Fossil Fuel GhG Emissions	Tonne/Year CO2 Eq	233,730K	242,259K	253,229K	269,788K	285,156K	293,916K	307,176K	324,241K	336,453K	351,377K	367,471K	380,539K	397,776K	412,136K	427,593K	441,836K	457,959K	486,259K	501,734K	520,201K	541,254K	562,596K	581,555K	597,917K	612,537K	632,560K
Industry GhG Emissions	Tonne/Year CO2 Eq	100,283K	101,287K	102,843K	104,548K	105,659K	106,789K	107,974K	109,328K	114,245K	120,275K	123,651K	125,181K	129,966K	138,197K	145,209K	149,626K	153,898K	160,236K	168,220K	176,657K	184,956K	193,496K	203,052K	213,733K	224,558K	234,647K
Services GhG Emissions	Tonne/Year CO2 Eq	2,591K	2,459K	2,353K	2,274K	2,219K	2,179K	2,163K	2,183K	2,242K	2,310K	2,349K	2,363K	2,401K	2,465K	2,531K	2,596K	2,671K	2,773K	2,895K	3,024K	3,168K	3,332K	3,512K	3,706K	3,912K	4,132K
Residential GhG Emissions	Tonne/Year CO2 Eq	32,852K	33,101K	33,371K	33,667K	34,000K	34,380K	34,796K	35,213K	36,019K	37,201K	38,049K	38,464K	39,646K	41,531K	43,026K	43,900K	44,777K	46,111K	47,763K	49,467K	51,087K	52,714K	54,556K	56,659K	58,790K	60,734K
Transportation GhG Emissions	Tonne/Year CO2 Eq	99,337K	102,461K	105,646K	109,427K	114,131K	118,708K	122,445K	126,148K	129,843K	133,127K	135,869K	137,660K	139,510K	141,474K	142,150K	141,354K	139,668K	138,351K	137,036K	134,322K	130,666K	126,663K	122,197K	116,911K	110,883K	104,686K
Cement GhG Emissions	Tonne/Year CO2 Eq	17,667K	18,193K	18,721K	19,257K	19,807K	20,381K	20,987K	21,629K	22,308K	23,027K	23,783K	24,574K	25,398K	26,254K	27,145K	28,071K	29,028K	30,016K	31,034K	32,090K	33,187K	34,330K	35,523K	36,772K	38,073K	39,414K
Other GhG Emissions	Tonne/Year CO2 Eq	20,005K	20,095K	20,204K	20,339K	20,502K	20,680K	20,861K	21,052K	21,441K	22,020K	22,434K	22,625K	23,204K	24,134K	24,859K	25,268K	25,677K	26,328K	27,152K	28,002K	28,822K	29,663K	30,624K	31,711K	32,801K	33,789K

Selected Results: Impact

Economic KPIs																											
Variable	Units	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Real Gross Domestic Product at Market Price	Real 2016 LCU	39.27B	77.38B	127.36B	180.80B	239.93B	303.20B	359.92B	423.63B	512.86B	670.78B	886.54B	1,058.76B	1,214.77B	1,361.08B	1,498.26B	1,623.34B	1,740.26B	1,845.11B	1,950.14B	2,059.72B	2,175.86B	2,287.84B	2,402.82B	2,523.20B	2,629.35B	2,748.64B
Real Agriculture Gross Value Added	Real 2016 LCU	10.04B	20.26B	34.06B	49.13B	65.94B	84.42B	101.28B	120.24B	146.24B	188.16B	244.54B	292.18B	333.75B	372.41B	407.14B	436.31B	462.23B	485.86B	508.64B	531.61B	555.30B	578.14B	602.43B	627.98B	651.35B	676.28B
Real Industry Gross Value Added	Real 2016 LCU	8.82B	16.03B	25.15B	34.93B	45.71B	56.82B	67.80B	79.30B	94.25B	119.85B	148.38B	174.66B	196.45B	220.16B	244.33B	264.94B	282.82B	298.74B	315.54B	332.08B	349.90B	370.42B	388.79B	406.37B	426.75B	445.62B
Real Services Gross Value Added	Real 2016 LCU	18.36B	37.08B	61.52B	87.35B	115.82B	146.21B	172.14B	202.08B	245.72B	327.93B	447.56B	536.92B	621.48B	697.81B	768.96B	837.77B	904.81B	964.68B	1,024.66B	1,089.04B	1,157.63B	1,220.45B	1,286.79B	1,357.78B	1,414.67B	1,483.97B
Total Real Imports	Real 2016 LCU	16.42B	29.76B	45.96B	63.69B	83.68B	105.41B	128.29B	149.72B	177.04B	220.79B	277.72B	326.81B	376.11B	422.47B	465.29B	506.88B	548.33B	585.68B	621.47B	658.54B	698.08B	737.00B	776.54B	818.46B	855.40B	897.94B
Total Real Exports	Real 2016 LCU	7.17B	14.43B	24.15B	34.81B	46.81B	59.83B	71.79B	85.29B	103.84B	135.95B	179.70B	215.31B	248.09B	279.10B	308.40B	335.33B	360.70B	383.91B	406.88B	430.83B	456.19B	480.79B	505.86B	531.95B	555.19B	581.29B
Real Total Investment	Real 2016 LCU	(20.59B)	(17.38B)	(12.91B)	(7.78B)	25.18B	(0.97B)	13.24B	24.82B	39.90B	125.22B	218.15B	249.17B	310.15B	305.03B	296.70B	284.13B	269.49B	284.21B	262.12B	273.83B	286.12B	335.90B	309.48B	358.12B	326.28B	425.61B
Total Net Hiring	People/Year	0.94K	(0.10K)	(3.22K)	(5.03K)	15.31K	(13.68K)	0.49K	(0.86K)	(5.03K)	32.07K	(15.43K)	(26.81K)	(25.68K)	(18.64K)	12.03K	23.83K	13.02K	19.08K	2.72K	(6.55K)	(18.76K)	22.24K	(5.05K)	(2.87K)	(14.42K)	20.83K
Agriculture Net Hiring	People/Year	(1.91K)	(0.08K)	0.78K	0.83K	6.97K	(0.27K)	3.11K	3.42K	4.30K	17.06K	13.95K	7.34K	5.36K	1.27K	2.62K	4.41K	3.36K	4.01K	1.55K	1.28K	(0.35K)	7.45K	0.16K	2.47K	(4.61K)	4.29K
Industry Net Hiring	People/Year	3.60K	0.46K	(0.40K)	(0.13K)	(11.76K)	4.34K	(1.64K)	(1.64K)	(0.89K)	(24.45K)	(14.95K)	1.04K	5.37K	14.17K	10.88K	6.60K	7.59K	1.98K	7.14K	6.92K	8.81K	(9.31K)	3.65K	(3.45K)	7.85K	(21.51K)
Services Net Hiring	People/Year	(0.74K)	(0.48K)	(3.59K)	(5.73K)	20.11K	(17.75K)	(0.99K)	(2.64K)	(8.44K)	39.47K	(14.43K)	(35.19K)	(36.41K)	(34.08K)	(1.47K)	12.82K	2.07K	13.09K	(5.98K)	(14.75K)	(27.22K)	24.10K	(8.86K)	(1.88K)	(17.67K)	38.05K

Social KPIs																												
Variable	Units	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	
Total Population	People	(0K)	(0K)	(1K)	(3K)	(5K)	(9K)	(14K)	(21K)	(31K)	(45K)	(75K)	(133K)	(206K)	(270K)	(272K)	(265K)	(260K)	(257K)	(254K)	(252K)	(250K)	(248K)	(248K)	(247K)	(247K)	(248K)	
Female Population	People	(0K)	(0K)	(1K)	(1K)	(3K)	(4K)	(7K)	(10K)	(15K)	(21K)	(36K)	(64K)	(100K)	(131K)	(132K)	(128K)	(126K)	(125K)	(123K)	(122K)	(122K)	(121K)	(121K)	(121K)	(121K)	(121K)	
Male Population	People	0K	(0K)	(0K)	(1K)	(2K)	(4K)	(7K)	(11K)	(16K)	(23K)	(39K)	(69K)	(106K)	(139K)	(140K)	(136K)	(134K)	(132K)	(131K)	(129K)	(128K)	(127K)	(127K)	(126K)	(126K)	(127K)	
Total Births	People/Year	(1K)	(1K)	(2K)	(3K)	(4K)	(6K)	(8K)	(11K)	(15K)	(25K)	(59K)	(80K)	(89K)	(36K)	(2K)	(3K)	(4K)	(4K)	(4K)	(4K)	(4K)	(4K)	(3K)	(3K)	(4K)	(4K)	
Total Deaths	People/Year	(0K)	(0K)	(0K)	(1K)	(1K)	(1K)	(1K)	(2K)	(4K)	(5K)	(8K)	(11K)	(13K)	(13K)	(10K)	(8K)	(7K)	(7K)	(6K)	(6K)	(5K)	(4K)	(4K)	(4K)	(3K)	(2K)	
Total Fertility Rate	Proportion	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.01	-0.01	-0.01	-0.03	-0.04	-0.04	-0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.0015	-0.0015	-0.0014	-0.0013	-0.0013	
Average Life Expectancy	Years	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.02	0.03	0.04	0.06	0.07	0.07	0.08	0.08	0.07	0.06	0.06	0.06	0.06	0.0507	0.0463	0.0425	0.0392	0.0348	
Female Life Expectancy	Years	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.02	0.03	0.05	0.06	0.08	0.08	0.09	0.08	0.07	0.07	0.06	0.06	0.06	0.06	0.0509	0.0466	0.0434	0.0412	0.0381
Male Life Expectancy	Years	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.02	0.03	0.05	0.06	0.07	0.07	0.07	0.06	0.06	0.06	0.06	0.05	0.0505	0.0459	0.0415	0.0371	0.0314	

Environmental KPIs																											
Variable	Units	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Proportion of Renewables in Total Final Energy Consumption	Proportion	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.04	0.04	0.04	0.04	0.05	0.07	0.07	0.08	0.09	0.10	0.12	0.13	0.15	0.16	0.18	0.19	0.20
Total Green House Gas Emissions	Tonne/Year CO2 Eq	8,521K	7,850K	6,648K	4,555K	1,112K	(2,881K)	(7,525K)	(13,226K)	(16,153K)	(17,823K)	(23,341K)	(32,783K)	(38,499K)	(40,694K)	(46,597K)	(58,177K)	(71,404K)	(84,199K)	(98,440K)	(114,784K)	(134,457K)	(157,168K)	(180,656K)	(202,702K)	(223,707K)	(245,441K)
Agriculture Fossil Fuel GhG Emissions	Tonne/Year CO2 Eq	0K	0K	0K	0K	0K	0K	0K	0K	0K	0K	0K	0K	0K	0K	1K	1K	1K	1K	1K	1K	1K	1K	1K	1K	1K	1K
Agriculture Non-Fossil Fuel GhG Emissions	Tonne/Year CO2 Eq	249K	504K	850K	1,233K	1,663K	2,135K	2,572K	3,069K	3,745K	4,838K	6,314K	7,569K	8,682K	9,720K	10,664K	11,464K	12,188K	12,887K	13,533K	14,195K	14,887K	15,560K	16,268K	17,005K	17,681K	18,417K
Industry GhG Emissions	Tonne/Year CO2 Eq	6,943K	6,710K	6,317K	5,562K	4,155K	2,945K	1,820K	578K	2,535K	5,467K	5,792K	4,346K	5,986K	10,828K	14,271K	15,013K	15,512K	17,848K	21,582K	25,537K	29,186K	32,945K	37,618K	43,389K	49,416K	54,858K
Services GhG Emissions	Tonne/Year CO2 Eq	(8K)	(21K)	(29K)	(32K)	(29K)	(19K)	6K	47K	110K	172K	193K	178K	177K	195K	208K	213K	221K	242K	275K	315K	361K	417K	489K	582K	694K	818K
Residential GhG Emissions	Tonne/Year CO2 Eq	813K	801K	788K	776K	763K	750K	735K	621K	646K	959K	1,043K	837K	1,356K	2,482K	3,168K	3,248K	3,351K	3,897K	4,714K	5,530K	6,264K	7,028K	7,986K	9,156K	10,347K	11,392K
Transportation GhG Emissions	Tonne/Year CO2 Eq	98K	(566K)	(1,701K)	(3,406K)	(5,867K)	(9,124K)	(13,098K)	(17,943K)	(23,625K)	(29,884K)	(37,383K)	(46,342K)	(55,631K)	(65,467K)	(76,859K)	(90,169K)	(104,852K)	(121,599K)	(141,561K)	(163,878K)	(189,137K)	(217,590K)	(248,088K)	(278,626K)	(308,380K)	(338,147K)
Cement GhG Emissions	Tonne/Year CO2 Eq	0K	0K	1K	2K	4K	7K	11K	17K	25K	34K	44K	55K	69K	89K	120K	157K	199K	247K	298K	353K	411K	470K	532K	595K	660K	725K
Other GhG Emissions	Tonne/Year CO2 Eq	426K	422K	421K	421K	423K	426K	429K	385K	411K	591K	656K	573K	862K	1,459K	1,831K	1,898K	1,976K	2,278K	2,718K	3,162K	3,571K	4,001K	4,539K	5,195K	5,876K	6,494K

